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SCHOOL SCIENCE AND MATHEMATICS

DECEMBER 1956

School Science and Mathematics

A Journal for All Science and Mathematics Teachers

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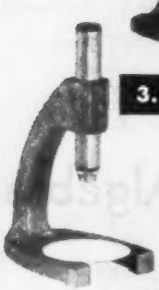

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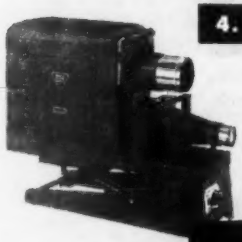

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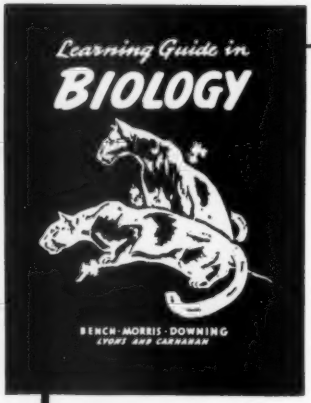

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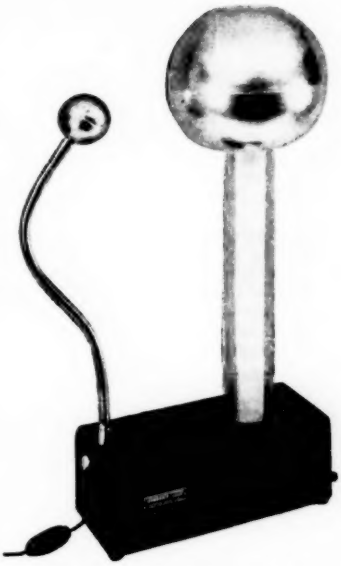

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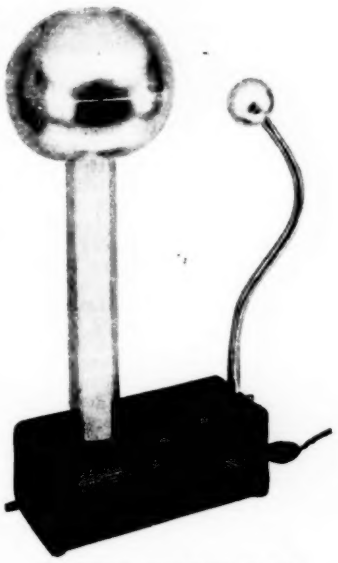

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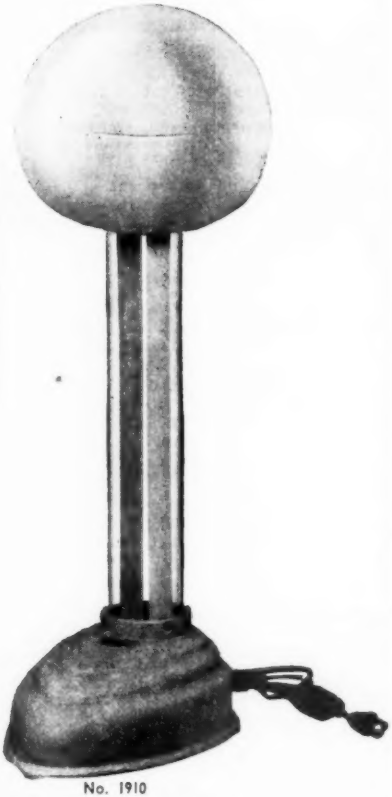

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SCHOOL SCIENCE
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VOL. LVI DECEMBER, 1956 WHOLE NO. 497

TIMESAVERS FOR THE GENERAL SCIENCE TEACHER

E. WAYNE GROSS
University School, Bloomington, Indiana

In the current school day, the general science teacher must teach five, six, and even seven classes. He is supposed to carry this load as efficiently as if teaching four or five classes.

To be able to work with individual students is the goal of all teachers. This takes more time, especially if the class size is thirty or more students. If any time can be saved in teaching procedures, such time can be devoted to the more demanding tasks of the classroom teacher. The following ideas and suggestions are offered as possible timesavers. No claim is made by the writer as to their origin or originality.

"If I could only get my students interested in science. I can't get them to do experiments and projects." Have you heard this expression? You want students to put forth extra effort, so why not give "extra-credit"? The writer has used the extra credit idea for several years to stimulate students to do experiments, bring in materials, and even help straighten up the laboratory. It is not a grade, but a "plus sign." The number of these plus signs can influence the six weeks grade. The degree to which extra credit affects the grade is influenced by the student's natural ability, effort and neatness. All of these are recognized factors to be considered in grading. The poorer student finds that the extra credit can help him maintain a passing grade. The average student is stimulated to try for that "B." The top students are led into areas of private interest and investigation in the fields of science.

"Yes, there are records to be kept." But, why not have a student

help you keep them? You, the teacher, select a class secretary. It will be his duty to keep track of the extra-credit work completed by the students. For this position, you will select one of your top students who is neat and accurate in his work.

It may be announced that all extra-credit work must be in by the end of the fifth week of the six weeks. Then in 15 minutes time you can go over all the extra-credit work for the class with the secretary. This could be done in class so the other students may know who does the extra-credit work and how much they do.

The class secretary can keep a record of the assignments for demonstrations, experiments, reports, and extra work done by the students. It will save time to assign all the demonstrations and experiments in a unit at one time. The secretary records the title of the demonstration and the names of the students volunteering to do the demonstrations. They receive extra-credit for doing the demonstration, so you will have plenty of volunteers. They also have the responsibility for bringing from home the materials used from outside sources.

The use of trays to contain the materials for each demonstration is a timesaver. In only a few minutes, you or one of your better students can assemble in separate trays the equipment needed for each demonstration. Trays $12'' \times 12'' \times 2''$ deep are satisfactory. They can be made of scrap strips of plywood and plaster board. A card containing information concerning the demonstration can be fastened on a top edge with a thumb tack.

The mention of tests and test grading touches on the basic philosophy of the teacher. If it is believed that tests make up only a part of a student's grade, then why not let students grade most of the tests? By giving two or three tests during a six weeks period, the individual test grade decreases in the fractional part of the whole grade.

The writer believes a test should be primarily objective with at least one essay type question. The objective part can be scored by the students, leaving for the teacher only the essay question and the grades to be placed on the papers.

Since grading is an important phase of a teacher's duties, why not take class time to do it? If you have a series of grades to average, let the students work in pairs and arithmetically average the grades. There are several advantages to this procedure. It is more accurate than a teacher's hurried estimate of the series of numbers or letters recorded in the grade book. The students, realizing how the grade is made out, will be more affable toward the teacher concerning the grade. Last, but not least it can become a timesaver.

If you use a workbook, why not let the students exchange and check the exercises? During the checking, any discussion of a question can be answered by the teacher. This again gives the entire class the

advantage of hearing the thoughts of others. If there is any cheating, the teacher will catch it, or other students will let it be known. In scoring, why take the time to subtract the errors from a perfect score? Add up the errors or check marks; list these sums on the board in ascending order. Then the teacher arbitrarily assigns grades for the exercise.

Some parts of units in general science can be handled primarily in the form of reports. It is an excellent learning experience for the students to take notes on these reports. Then have the student giving the report turn in a stated number of objective questions about his report. Then all of these can be screened by the teacher and form the basis for the test on that part of the unit.

In all of these suggestions the teacher is actually making the student a part of the learning situation. Students appreciate having a share in the planning and evaluating of any class situation. Let them help, so the classroom teacher can devote his time to help the students develop as individuals.

NATIONAL PARK SYSTEM HAS 40TH ANNIVERSARY

The nation celebrated the 40th anniversary of the National Park Service with the start of one of the most important decades in National Park Service history.

The reason: Mission 66.

Mission 66 is turning the attention of conservationists and Park Service officials from the 40th to the 50th anniversary. That is the date Mission 66, the biggest improvement program in Park Service history, will be completed. By then roads will have been improved and housing facilities increased, although moved away from scenic areas, to accommodate one of the nation's fastest growing enterprises.

Since the establishment of the National Park Service on Aug. 25, 1916, it has seen an almost continuous increase in visitors, with the exception of the World War II years. This is partly attributable to the efforts of the Service's first director, Steven T. Mather, who during his 12 years in office (1917 to 1929) did much to stimulate public consciousness of the National Park System. Mr. Mather helped launch the park interpretive program which, with its museums and scientist-guides, has been an educational boon to tourists.

During Mr. Mather's administration the Park System was largely confined to western United States. But under the Reorganization Act of 1933 President Roosevelt integrated into the system many monuments and reservations in the East and South which had been administered by the U.S. Forest Service and War Department. This made the Park System truly national.

During World War II, park attendance dropped from 21,000,000 persons annually to a low of 4,000,000 in 1943. Parks were practically stripped of personnel and many facilities could not be maintained. But attendance jumped back to its old level right after the war, and soon swelled under the influence of one of the greatest travel booms in history. It hit a peak of 50,000,000 last year.

During the past 11 years Federal park appropriations have been small, owing to the need for defense money. But the recently launched Mission 66 program, which anticipates a Federal expenditure of more than $17,000,000 on Yellowstone Park alone, will make up for this.

LIVING THINGS: AN ELEMENTARY SCHOOL SCIENCE UNIT

ALPHORETTA FISH
Bowling Green State University, Bowling Green, Ohio

In order to function effectively, the young child *needs* to develop a feeling of belonging to *his* world. Even more important, he *needs* to feel secure in this relationship. Science activities can be planned to help the child satisfy these needs realistically. In fact, this is an important function of elementary-school science.

The following unit is designed to (1) present concepts in such a way as to enable the child to see his relationship to other living things, (2) build a feeling of security based upon the concept that man has the ability to control his environment, and (3) emphasize that man benefits from his superiority only to the degree that he uses his ability wisely.

Animals:

1. Consider: Animals that live on the land. Observe and discuss:
   a) How are they all similar?
      (1) need for food
      (2) need for water
      (3) need for air
      (4) need for rest
      (5) need for shelter and protection
   b) How do they differ?
      (1) appearance: color, size; quills, feathers, fur
      (2) action: run, hop, fly, crawl; move fast, slow
      (3) special abilities: sight, smell, hearing; migration, hibernation

   Relate these differences to special ways animals have of securing their needs.
2. Consider (in a like manner):
   a) Animals that live in the water
   b) Animals that live both on land and in the water
3. In what ways are *all* animals similar?
4. Consider: Man
   a) In what ways is man similar to all animals?
   b) In what ways are some animals superior to man?
      (1) sight
      (2) hearing
      (3) speed
      (4) smell
      (5) strength
   c) How does man make up for his lack in these areas?

   Discuss how man has learned to use and control the things around him to produce radio, television, telephone, radar, automobiles, airplanes, etc.
   d) How is it possible for man to use and control the things around him for his comfort, convenience, and happiness?

   Conclude that of first importance is man's large brain which enables him to think. Discuss also man's hands with opposing thumbs and his ability to walk upright.
5. How can boys and girls use their brains to benefit themselves and others? Relate to health, safety, and problem solving.

Plants:

1. How are plants similar? Experiments:
   a) Do plants need water?
   b) How plants get water.[1]
   c) Do plants need sunshine?
   d) Do plants need air?
   e) Do seeds need warmth?[2]
2. How do plants differ? Observe:
   a) Do all plants die in the winter?
   b) In what ways do plants store food?
   c) Do all plants have seeds?
   d) Do all plants live on land?
   e) Are all plants edible?
3. How are plants similar to animals? to man? Generalize as to the common needs of all living things (food, water, air, protection).
4. In what special way do green plants differ from other living things?
   Green plants can *make* food from (1) sunshine, (2) air, (3) water, and (4) minerals.
5. Consider:
   a) Animals cannot make food for themselves
   b) Animals could not live without plants. They must eat plants for food or eat other animals that do eat plants.
   c) Man must eat plants for food or eat animals that do eat plants.
6. Discuss:
   a) Other uses of plants: lumber, medicine, fuel, cloth, rubber, shelter for animals, recreation and beauty for man.
   b) Man's obligation and responsibility to use his special brain wisely to protect and conserve both plant and animal life.
   c) What can boys and girls do to protect and conserve plant and animal life?

Activities:

1. Observations:
   a) What do animals eat?
   b) Where do they find their food?
   c) How do animals move about?
   d) How do animals breathe?
   e) How do animals care for and train their young? Relate to the child and his parents, the school.
   f) Where do animals build their homes?
   g) How do animals prepare for winter?
      (1) store food
      (2) hibernate
      (3) migrate
   h) How do plants prepare for winter?
   i) How does man prepare for winter?
2. Make an aquarium. Discuss the function of the plant life.
3. Demonstrate "hibernation" by allowing a frog to hibernate in a refrigerator.
4. Trace meat, eggs, cheese, butter, maple sugar, etc. to their plant origin.
5. Discuss:
   a) Parts of plants we eat:
      (1) leaf (lettuce)
      (2) root (carrot)
      (3) seed (pea)
      (4) stem (celery)
      (5) underground stem (potato)

[1] Wyler, Rose. *First Book of Science Experiments.* New York: Franklin Watts, Inc., 1952, pp. 38–9.
[2] *Loc. cit.*, p. 37

b) Importance of plant food to the health and happiness of man and the place of certain foods in a well-balanced diet.

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CANCER RESEARCH

A University of Wisconsin scientist Thursday said that cancer research is becoming such a complex field—with new findings pouring in from every quarter—that a new kind of researcher is needed to bring order out of chaos.

He said large cancer centers might profitably include a young scientific team whose only job would be to help keep abreast of all discoveries and act as research strategists and tacticians in the cancer battle.

The scientist who made the proposal is Dr. Van R. Potter of the University of Wisconsin's McArdle Laboratory for Cancer Research, one of eight laboratories in the nation devoted exclusively to basic cancer research.

He put forth the idea in a guest editorial in the September issue of *Cancer Research*, a technical journal in which cancer scientists report their latest findings.

Cancer research, Potter said, has now reached the stage of development where it has broken down into specialties. A vast amount of basic knowledge is available—but specialists in one field usually do not have time to keep abreast of developments in their own field and all of the others too.

If someone could bring all this knowledge together, Potter said, medicine's understanding of cancer might progress by leaps and bounds. He added that teams of four young scientists, each a specialist in a different field, might be just the theoretical general headquarters needed in the war against cancer.

PARALLELOGRAMS WITH INTEGER SIDES AND DIAGONALS

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In the October, 1955, issue of SCHOOL SCIENCE AND MATHEMATICS, Norman Anning proposes the problem (No. 2483) of giving a method for finding all parallelograms whose sides and diagonals are integral numbers of units of length. He provides the following examples of such parallelograms:

Sides	Diagonals
8, 9	11, 13
11, 13	16, 18
16, 18	22, 26

Thus far (March, 1956) no general solution of Anning's problem has appeared in this journal, although Joan Doersching has offered a method (SCHOOL SCIENCE AND MATHEMATICS, Vol. LVI, No. 2, p. 156) which yields a family of parallelograms meeting the conditions of the problem. Doersching's partial solution is apparently the same employed by Anning in constructing his examples. The following treatment of the problem endeavors to discover a means of finding *all* parallelograms satisfying the stipulated conditions.

Consider a general parallelogram of sides a, b and diagonals c, d as shown in Fig. 1.[1] We have from the figure,

$$\begin{aligned} c^2 &= (a+b\cos\theta)^2+b^2\sin^2\theta \\ &= a^2+2ab\cos\theta+b^2\cos^2\theta+b^2\sin^2\theta \\ &= a^2+2ab\cos\theta+b^2 \qquad (1) \\ d^2 &= (a-b\cos\theta)^2+b^2\sin^2\theta \\ &= a^2-2ab\cos\theta+b^2\cos^2\theta+b^2\sin^2\theta \\ &= a^2-2ab\cos\theta+b^2 \qquad (2) \end{aligned}$$

from which

$$c^2+d^2 = 2a^2+2b^2 = 2(a^2+b^2) \qquad (3)$$

This result holds, of course, whether the numbers a, b, c, d be integers or not.

Suppose that all four numbers a, b, c, d are integers. Then since the right side of (3) is an even number, the integers c^2 and d^2 on the

[1] My thanks are due to Mr. Ralph Gilman for preparing the figures.

left must either both be odd or both be even. But the square of an odd number is odd, while the square of an even number is even; hence c and d must both be odd or both be even, according as their squares are odd or even.

Let c and d both be even; then we may write $c=2p$ and $d=2q$ (p and q integers), and we have in (3):

$$(2p)^2+(2q)^2=4(p^2+q^2)=2(a^2+b^2),$$

whence

$$a^2+b^2=2(p^2+q^2) \tag{4}$$

so that a and b, by the same argument as for c and d, must both be odd or both be even. Hence, if the sum or the difference of a and b is an even number, c and d will both be even. If the sum or the difference of a and b is an odd number (*i.e.*, if *one* of the numbers a, b is odd and the other even), then c and d will both be odd.

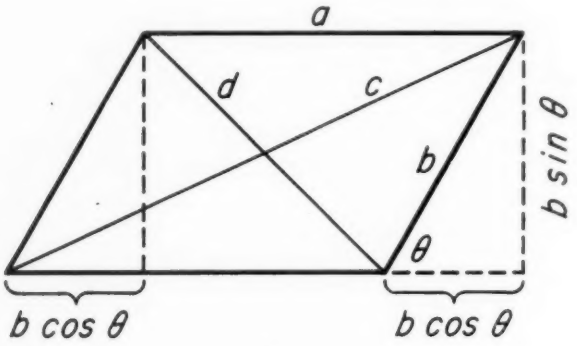

FIG. 1

Returning to Fig. 1, we immediately distinguish two special cases: (1) that in which $\theta=0$ so that the parallelogram collapses (degenerates) into a straight line, and (2) that in which $\theta=90^\circ$ so that the figure is a rectangle.

In case (1) we have $\cos\theta=\cos 0=1$, whence from eq. (1),

$$c^2=a^2+2ab+b^2=(a+b)^2$$

so that

$$c=a+b \tag{5}$$

and from eq. (2),

$$d^2=a^2-2ab+b^2=(a-b)^2$$

whence

$$d = a - b \tag{6}$$

In such a degenerate parallelogram, then, the greater diagonal is equal to the sum of two adjacent sides, while the lesser diagonal is equal to the difference of the two adjacent sides.

In the second special case ($\theta = 90°$), we have $\cos\theta = \cos 90° = 0$, therefore from (1),

$$c^2 = a^2 + b^2 \quad \text{or} \quad c = \sqrt{a^2 + b^2} \tag{7}$$

and from (2),

$$d^2 = a^2 + b^2 \quad \text{or} \quad d = \sqrt{a^2 + b^2} \tag{8}$$

i.e., the two diagonals are equal, each being the hypotenuse of a right triangle whose legs are a and b.

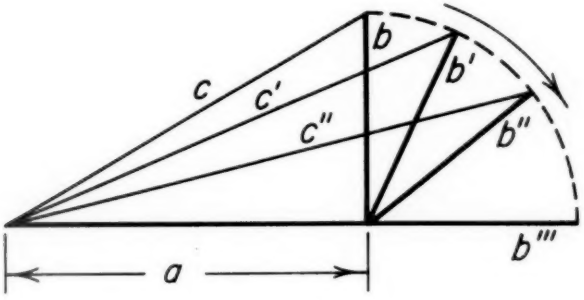

FIG. 2

Now consider what happens to a parallelogram of given constant sides a, b when the angle θ decreases continuously from 90° to zero. Initially the figure is a rectangle in which $c = \sqrt{a^2 + b^2}$, which may or may not be an integer. (We assume the sides a and b to be integral.) Fig. 2 illustrates four stages in the process of collapsing the rectangle into a straight line (for simplicity we show only one pair of adjacent sides, and only one diagonal, c).

As θ decreases, c increases until, when $\theta = 0$, c has the integer value $a+b$. Thus as θ assumes all values from 90° to 0, c will assume all values from $\sqrt{a^2+b^2}$ to $a+b$. If there are any integers within this range, c will have these integer values for certain positions b', b'', etc. of the side b. For each such integral value of c, we may then test whether

$$d^2 = 2(a^2 + b^2) - c^2 \tag{9}$$

is a perfect square. If so, then d is of course an integer.

It will not be necessary to examine every integer value of c between the limits $\sqrt{a^2+b^2}$ and $a+b$, since we already know that only odd values will satisfy eq. (3) when $a+b$ is odd, and only even values of c need be considered when $a+b$ is even. We also know that in the case of the degenerate parallelogram the longer diagonal has its maximum value $c=a+b$, and the shorter diagonal has its minimum value $d=a-b$. Therefore, any other integral values which the diagonals may have (satisfying eq. (3)) when θ is between 0 and 90° must be of the forms

$$c=(a+b)-2k \tag{10}$$

$$d=(a-b)+2l \tag{11}$$

where k and l are positive integers.

Substituting the right sides of (10) and (11) into eq. (3) we have

$$(a+b-2k)^2+(a-b+2l)^2=2(a^2+b^2)$$

or expanding the left side,

$$(a+b)^2-4k(a+b)+4k^2+(a-b)^2+4l(a-b)+4l^2$$
$$=2(a^2+b^2)=(a+b)^2+(a-b)^2$$

whence

$$-4k(a+b)+4k^2+4l(a-b)+4l^2=0,$$

from which we obtain, by transposing the first two terms and dividing through by 4,

$$l(a-b+l)=k(a+b-k) \tag{12}$$

When the sides a and b are both given, our problem reduces to that of determining what integral values of l will satisfy eq. (12) when k is given the successive values 1, 2, 3, $\cdots$. Each integer l thus found may be substituted into eq. (11), and the corresponding k into (10); a and b being given integers, we will then also have integral values for the diagonals c and d. But this process, though far easier than the direct solution of eq. (9), is still rather tedious.

Subtracting (11) from (10) we get

$$c-d=2b-2(k+l) \tag{13}$$

and if our parallelogram is a rectangle then $c=d$ and the right side of (13) is zero. In this case,

$$b=k+l \tag{14}$$

If the parallelogram is not rectangular, we will have $d<c$, from which

$$2b-2(k+l)>0, \quad \text{or} \quad b>k+l.$$

In any event, then, we must have $b \geqq k+l$.

Now adding (10) and (11),

$$c+d=2a+2(l-k) \tag{15}$$

whence

$$\tfrac{1}{2}(c+d)=a+l-k.$$

It is evident from Fig. 1 that except in the degenerate case, $\frac{1}{2}(c+d) > a$; therefore in the preceding equation,

$$a+l-k>a$$

from which

$$l-k>0 \quad \text{or} \quad l>k \tag{16}$$

As we must have $k \geqq 1$ in any non-degenerate parallelogram, the inequality (16) assures us that in any such parallelogram we must have $l \geqq 2$, and consequently we will always have $b \geqq 3$.

The three conditions for any non-degenerate parallelogram,

$$k \geqq 1, \qquad l>k, \qquad b \geqq k+l,$$

impose limitations on the pairs of numbers (k, l) to be put into eq. (12) for trial when b is given. For example, when $b=3$, the only pair of numbers (k, l) to be tested in eq. (12) is (1, 2); for $b=4$ we need try only the two pairs (1, 3) and (1, 2), since the pair (2, 2) is precluded by the requirement that $l>k$.

The fact that the specification of b allows us to determine the possible integer-pairs (k, l) which may be substituted into eq. (12) suggests that we solve this equation for a in terms of b, k, and l. Thus from (12),

$$(l-k)a=(k+l)b-(k^2+l^2).$$

For the moment let us write $l-k=u$, so that $l=k+u$ and $l+k=2k+u$; then this last equation takes the form

$$ua=(2k+u)b-(2k^2+2uk+u^2),$$

which quickly reduces to

$$a=b-2k-u+\frac{2k}{u}(b-k).$$

Substituting back $l-k$ for u, we obtain

$$a=b-(k+l)+\frac{2k(b-k)}{l-k} \tag{17}$$

Since b, k, and l are integers, a will be an integer whenever the last term of (17) is integral. It is immediately obvious that this will be the case when $l-k$ is equal to 1 or 2, as well as when $l=2k$ and $l=3k$. Every integer a thus obtained will be one side of a parallelogram whose adjacent side is the integer b, and whose diagonals are the integers c and d found by substituting a, b, k, and l into eqs. (10) and (11).

To illustrate the procedure with a few simple examples, we may start with the simplest case, $b=3$. For this we have, in accordance with our three conditions, the single pair of values (1, 2) for (k, l). Denoting the last term of (17) by r, we find its value to be

$$r=\frac{2\cdot 1(3-1)}{2-1}=4,$$

hence

$$a=3-(1+2)+4=4,$$

and now by (10) and (11),

$$c=(4+3)-2\cdot 1=5,$$
$$d=(4-3)+2\cdot 2=5,$$

so that we have the rectangle of sides 4 and 3, and diagonals 5 and 5. We may recall here that in every rectangle $b=k+l$, so in (17) $a=r$.

When $b=4$, our integer-pairs (k, l) are (1, 3) and (1, 2), both of which yield integer values for a in (17). Thus,

$$\begin{aligned} b=4, \quad (k, l)=(1, 3), \quad & a=4-4+3=3 \\ & c=3+4-2=5 \\ & d=3-4+6=5 \\ (k, l)=(1, 2), \quad & a=4-3+6=7 \\ & c=7+4-2=9 \\ & d=7-4+4=7 \end{aligned}$$

Let us denote a parallelogram of sides a, b and diagonals c, d by the notation $(a, b; c, d)$, the sides being written before the semicolon, the diagonals after it. As we have just seen, then, when $b=4$ and $(k, l)=(1, 3)$ we again get the rectangle (3, 4; 5, 5), while when $b=4$ and $(k, l)=(1, 2)$ we obtain the new parallelogram (7, 4; 9, 7).

For $b=5$ we have the possible (k, l) pairs: (1, 4), (1, 3), (2, 3), (1, 2). The last three of these will clearly give integer values for a in (17), since the differences $l-k$ in these pairs are 2, 1, and 1 re-

spectively, all of which divide into the numerator of the final term r in eq. (17). But for the pair (1, 4) we have

$$r=\frac{2\cdot 1(5-1)}{4-1}=8/3,$$

hence the numbers $k=1, l=4$ will not yield integral values for a, c, and d when substituted into eqs. (17), (10), and (11). For the remaining three pairs of (k, l) values we find:

$$\begin{aligned} b=5,\quad & (k, l)=(1, 3), \quad a=5, \quad c=8, \quad d=6 \\ & (k, l)=(2, 3), \quad a=12, \quad c=13, \quad d=13 \\ & (k, l)=(1, 2), \quad a=10, \quad c=13, \quad d=9 \end{aligned}$$

Thus the requirements of Anning's problem are satisfied by the rhombus (5, 5; 8, 6), the rectangle (12, 5; 13, 13), and the parallelogram (10, 5; 13, 9).

As a final example, which we need not work out here in detail, let us take $b=10$. We have twenty possible (k, l) pairs as follows:

$$\begin{array}{cccccccc} (1,2) & (1,3) & (1,4) & (1,5) & (1,6) & (1,7) & (1,8) & (1,9) \\ & (2,3) & (2,4) & (2,5) & (2,6) & (2,7) & (2,8) & \\ & & (3,4) & (3,5) & (3,6) & (3,7) & & \\ & & & (4,5) & (4,6) & & & \end{array}$$

From these twenty pairs we can at once select ten which will make the last term of eq. (17) an integer, namely:

those in which $l-k=1$: (1, 2), (2, 3), (3, 4), (4, 5),

those in which $l-k=2$: (1, 3), (2, 4), (3, 5), (4, 6),

those in which $l=2k$: (3, 6),

those in which $l=3k$: (2, 6).

The remaining ten pairs of numbers (k, l) must be examined by substitution into the last term of (17); by this process we find that (1, 4) and (1, 7) are the only ones making r an integer.

The method described above will yield all parallelograms having integer sides and diagonals, though obviously for ever-larger values of b the process becomes increasingly laborious. However, some parallelograms may be determined quite easily once we have found a few by eqs. (17), (10), and (11).

Most obvious is the class of all similar parallelograms in which the ratio of similitude is an integer. If we know a particular parallelogram $(a, b; c, d)$ in which these four numbers are integers, we can immediately construct the similar parallelogram $(na, nb; nc, nd)$

where n is any integer greater than unity. Thus, let $n(a, b; c, d)$ denote the process of expanding each linear dimension of $(a, b; c, d)$ by the factor n; we have then

$$n(a, b; c, d) = (na, nb; nc, nd) \tag{18}$$

For example, from the parallelogram (8, 9; 11, 13) we obtain the infinitude of similar figures:

$$2(8, 9; 11, 13) = (16, 18; 22, 26)$$

$$3(8, 9; 11, 13) = (24, 27; 33, 39)$$

etc.

Another family of parallelograms with integer sides and diagonals may be obtained by the method suggested by Joan Doersching, already alluded to. We note that eq. (4) has the same form as eq. (3); hence the integers p and q in (4) may be regarded as the sides of a parallelogram having the integers a and b as diagonals. But a and b are adjacent sides of a parallelogram with diagonals $c = 2p$ and $d = 2q$. Therefore, from a given parallelogram $(a, b; c, d)$ we may construct another having the sides $a' = c$, $b' = d$, and the diagonals $c' = 2a$, $d' = 2b$. This process may be symbolized by the notation

$$(a, b; c, d) \rightarrow (c, d; 2a, 2b) \tag{19}$$

Anning's examples are constructed in this way, for by (19),

$$(8, 9; 11, 13) \rightarrow (11, 13; 16, 18)$$

$$(11, 13; 16, 18) \rightarrow (16, 18; 22, 26).$$

However, every parallelogram thus derived, after the first, will be simply the double of the second preceding figure. From (19),

$$(c, d; 2a, 2b) \rightarrow (2a, 2b; 2c, 2d) = 2(a, b; c, d)$$

$$(2a, 2b; 2c, 2d) \rightarrow (2c, 2d; 4a, 4b) = 2(c, d; 2a, 2b)$$

etc.

We may inquire if, given two distinct parallelograms $(a, b; c, d)$ and $(a', b'; c', d')$, we may obtain a third by taking the sum or the difference of corresponding sides and diagonals of the given parallelograms, and under what circumstances this may be possible. Let us adopt the hypothesis that

$$n(a, b; c, d) + m(a', b'; c', d') = (na + ma', nb + mb'; nc + mc', nd + md') \tag{20}$$

where each letter denotes an integer, and one of the numbers n, m may be negative.

Putting the quantities of the right side into eq. (3) we have

$$\begin{aligned}(nc+mc')^2+(nd+md')^2 &= (nc)^2+2mncc'+(mc')^2+(nd)^2+2mndd'+(md')^2\\ &= 2(na+ma')^2+2(nb+mb')^2\\ &= 2(na)^2+4mnaa'+2(ma')^2+2(nb)^2+4mnbb'+2(mb')^2.\end{aligned}$$

But

$$\begin{aligned}(nc)^2+(nd)^2 &= 2(na)^2+2(nb)^2,\\ (mc')^2+(md')^2 &= 2(ma')^2+2(mb')^2,\end{aligned}$$

so that

$$2mn(cc'+dd') = 4mn(aa'+bb')$$

or

$$cc'+dd' = 2(aa'+bb') \tag{21}$$

Thus if our two original parallelograms satisfy eq. (21), we may add any multiple of one to any multiple of the other, and obtain a new parallelogram with integer sides and diagonals. From an arbitrary multiple of one we may also subtract any such multiple of the other that the following two conditions are not violated:

1) None of the lengths on the right side of (20) may be zero or negative;

2) The longer diagonal on the right side of (20) may not be greater than the sum of the two sides, and the shorter diagonal may not be less than the difference between the two sides.

Equation (21) is in fact satisfied by the two parallelograms $(a, b; c, d)$ and $(c, d; 2a, 2b)$, in which we have

$$cc' = 2ac, \quad dd' = 2bd, \quad aa' = ac, \quad bb' = bd.$$

These quantities when put into (21) make the expression an identity.

By use of eqs. (19) and (20) we can find an enormous variety of parallelograms with integer sides and diagonals from a single initial parallelogram. For instance, as already shown, from (17), (10), and (11) we can get the rectangle (4, 3; 5, 5). Now by (19),

$$(4, 3; 5, 5) \rightarrow (5, 5; 8, 6)$$

and these two parallelograms satisfy eq. (21), hence they may be used in eq. (20) to find further parallelograms with integral dimensions. Write $(4, 3; 5, 5) = P$ and $(5, 5; 8, 6) = P'$; then by (20),

$$P+P' = (4, 3; 5, 5)+(5, 5; 8, 6) = (9, 8; 13, 11)$$

which is the first in Anning's list. Moreover,

$$2P+P' = (8, 6; 10, 10)+(5, 5; 8, 6) = (13, 11; 18,16)$$

$$P+2P' = (4, 3; 5, 5)+(10, 10; 16, 12) = (14, 13; 21, 17)$$

$$3P-P' = (12, 9; 15, 15)-(5, 5; 8, 6) = (7, 4; 7, 9)$$

$$2P'-P = (10, 10; 16, 12)-(4, 3; 5, 5) = (6, 7; 11, 7)$$

and so on. Clearly this sort of operation can be continued indefinitely.

The results given in the foregoing discussion suggest certain further investigations, such as the use of eq. (17) in generating Pythagorean number-triples; but at present such studies would take us too far from our principal topic.

DRESS REHEARSAL FOR SATELLITE OBSERVATIONS

A dress rehearsal for amateur astronomers observing the earth-circling satellites during the International Geophysical Year will be held in the United States within the next three months.

Plans for the dry-run practice tracking of moonlets in late November or early December were announced in a speech prepared for delivery today in Barcelona, Spain, by Dr. Fred L. Whipple, Harvard University astronomer and director of Smithsonian Astrophysical Observatory, which is in charge of visual observations of the satellites. This program is called Moonwatch.

The "invaluable" practice Moonwatch will also provide the "first, large-scale" search for any possible undiscovered natural earth satellites, Dr. Whipple told the international meeting of about 300 scientists gathered in Barcelona to make final plans for the International Geophysical Year. IGY, in which about 50 nations will participate, is a world-wide study of the earth, its seas and its atmosphere scheduled to start next July 1.

Dr. Whipple also issued an invitation to astronomers of all countries, including Russia, to cooperate in the optical tracking programs.

This, he said, was divided into three phases:

1. A photographic program involving the use of 12 especially designed, wide-eyed Schmidt cameras placed at 21 or more stations around the world.

2. A visual observation program, involving volunteer groups of observers over the world, using simple optical aids to locate each satellite launched, of particular value in the beginning and final stages of any satellite's life.

3. A professional astronomers' program, using special equipment in observatories.

A central computing bureau is being set up in Cambridge, Mass., Dr. Whipple said, to provide immediate analysis of both precision photographic and approximate visual observations from which will be made predictions of the paths to be taken by the satellites. The high-speed electronic computer will also be used to analyze the combined observations for geophysical and astronomical results.

NEW ADDRESS OF JOHN F. RIDER PUBLISHER

The John F. Rider Publisher, Inc., is now located at a new address, 116 West 14 Street, New York 11, New York.

Expanding operations in textbook publishing and in the publishing of material for the servicing industry made necessary relocation in larger quarters and a major enlargement in the shipping facilities.

DEVELOPING THE PHYSICS AND CHEMISTRY LABORATORY IN THE SMALL HIGH SCHOOL

C. CHAPPLE
Silver Lake High School, Silver Lake, Indiana

I would first like to define what, in this case, is referred to as a small high school. The high school upon which this paper is based has an enrollment of 108 students. This is the largest enrollment in its history. The average for the past twenty years has been approximately 75 students.

The laboratory in this high school is equipped to carry out all the laboratory exercises in any of the currently used laboratory manuals in both high school physics and high school chemistry.

The topic of this paper is how was this small high school laboratory developed? I have been teaching the science in this high school for the past twenty years, and have been working on the development of its laboratory for that length of time. Therein lies part of the answer to how this laboratory was and has developed.

PATIENCE. It takes time to develop a reasonably complete and workable laboratory in a small school. I don't believe a laboratory plan is ever complete. Improvements can always be made. Although our laboratory has been reasonably workable for the past ten years, I haven't ceased to add improvements as I saw the need for them.

PLANNING. Another important factor, as I see it, is a plan. Have a plan, and then work the plan. In the beginning I had a mental picture of what I would like to see our school have in the way of a laboratory. Then I started out to fill in the details of that vision or picture. Changes were made now and then in the plan as an idea would strike which appeared to be an improvement. But, the general picture remained the same—that of developing a laboratory to take care of all high school level experiments and demonstrations. Little by little, this was accomplished.

ENTHUSIASM. Next I would consider enthusiasm on the part of the teacher as an absolute must if a small school laboratory is ever to be realized. One must have his heart and soul in the teaching of science. Enthusiasm is catching. If you are truly enthusiastic, soon your students are enthusiastic. They will carry this enthusiasm outside the school. When the trustees get favorable reports from parents and taxpayers as to the work done and interest taken by the students in a certain department, in this case science, he is going to be more willing to spend on that department. The enthusiasm to which I refer is not just the surface, skin deep, put-on type. Rather, it is the kind that causes those who know you the best, your family and close

friends to say, "I believe he would rather teach science or work in the laboratory than eat."

INDUSTRY. If one is truly enthusiastic in his work, it naturally leads to being industrious. You will do some work for which you do not get paid. Cabinets may be needed and acquired by offering to build them yourself if the trustee will furnish the materials. Tables may be converted into chemistry desks in the same manner. They may not be as good, nor as fancy as custom built ones, but at least you have them, and can plan toward the better ones at a later date. If you show you are willing to give a little of yourself beyond the call of duty, the community will often respond by matching your efforts with their money. A little donated work on your part for a few nights or Saturdays may pay big dividends in your effort to develop a good laboratory.

REASON. Give your trustee a reason for the need of the equipment and supplies for which you are asking. I take it that you as a science teacher are interested in the WHY and HOW of things. Your trustee is interested in the WHY. Science can be taught from books alone, but even the best of teachers would do only a mediocre job that way. Laboratories are needed to produce well trained science students just as stoves are needed to produce well trained cooks. Don't be demanding. Present your needs as essentials, but not as musts. You can teach just from the book, but if learning is to be made easier and more permanent, laboratory equipment and supplies are essential. It may mean more work for you, the teacher, but you are interested in your school giving the students as much training as is possible. Try to sell these facts to the trustee and the community.

USABLE EQUIPMENT. When developing a laboratory in a small school be certain to put considerable thought into what to purchase first. Everyone realizes that everything needed cannot be purchased the first year. School budgets will not stretch that far. The sequence of acquiring equipment is an important item to be considered. Plan to get those items which you will be able to put to the most use in a year's schedule, or those items which will be most beneficial in making the more difficult facts clearer. Laboratory exercises are of little value unless they help to clarify a fact. Spectacular equipment for show may have a place, but in a small school it should be left until last for purchase. People may get the idea that your laboratory is only for entertainment. Therefore, be careful to put first things first.

COMMUNITY SERVICE. When students and parents begin to bring problems to you for explanation, you can feel you are having a degree of success. Whether it be a radiosonde, a small item for electroplating, soil to test, or just a question along scientific lines, don't

disappoint them. If you do not know the answer, offer your services in trying to find out for them. Then make an honest effort to do so.

NO LABORATORY FEES. We have never established a laboratory fee. We do hold students responsible for breakage. I have always worked on the premise that with no laboratory fee the entire responsibility of the building and upkeep of the laboratory belongs to the school. This also precludes the argument that the laboratory fee should take care of the laboratory.

The points I have referred to in this paper are some of the things I would consider important as I look back over my experience in developing a science laboratory in a small high school. I would like to emphsize that of the items I have mentioned—A PLAN, PATIENCE, ENTHUSIASM, and INDUSTRY are musts.

FOREIGN TEACHING POSTS

Foreign Teaching Posts will be available in Army-operated schools for American children in Germany, France, Italy, Japan and Okinawa for the 1957–58 school year. The greatest number of vacancies will be for elementary teachers experienced in the primary grades. Secondary teachers who qualify in two major fields will be needed also. In addition to regular academic subjects, industrial arts, arts and crafts and homemaking are offered in many of the high schools. Opportunities generally exist for school librarians, guidance counselors and dormitory supervisors. A limited number of administrative positions are expected.

General qualifications include a bachelor's degree, 18 semester hours credit in education courses, at least two years recent experience at the grade level for which applying and a valid teaching certificate. Age: Minimum—25, maximum—55. Women must be single, without dependents.

Salary for the instructional staff is $377 monthly with free transportation overseas and return. An additional 10% of base pay is offered for duty on Okinawa, a modern post of assignment. Rent-free living quarters are available in most areas. Minimum tour of duty is one year.

To assure consideration for the coming school year, inquiry regarding application procedure should be made prior to 1 December 1956 to Overseas Affairs Division, Office of Deputy Chief of Staff for Personnel, Department of Army, Washington 25, D. C.

THE KEYSTONE VISUAL-SURVEY SHORT TESTS

In response to a demand for cutting down the time required to administer the Keystone Visual-Survey Service Tests to large numbers of students, Keystone View Company has released the Keystone Visual-Survey Short Tests.

These tests consist of eleven tests on three cards and can be administered by the nurse or teacher in about one minute. Furthermore, since it is not recommended that the students be referred when failing on any one of the tests in this Short Series, the testing may be terminated on the first failure and the student then put through the complete series of tests. Since at least 50 per cent of the students will pass this Short Test, administered in an average of about one minute, it is easy to see that a great deal of time can be saved in testing a large number of students.

Detailed information may be had upon request from the Keystone View Company, Meadville, Pennsylvania.

A DEMONSTRATION ON "CENTRIFUGAL" FORCE, ANGULAR MOMENTUM, WORK AND ENERGY. VERIFICATION OF $F=mv^2/r=m\omega^2r=4\pi^2f^2mr$ BY SIMPLE MEANS

JULIUS SUMNER MILLER
El Camino College, El Camino College, California

The experiment reported here demonstrates a phenomenal array of *fundamental* physics in an elementary way. Although essentially qualitative and demonstrative it can yield reliable quantitative results.

I. Fire-polish the ends of a 6-inch length of glass tubing. Pass through the tube a stout string about a meter long. To one end fix a 10-gram mass (a hooked-weight will do); to the other end fix a 200-gram mass. With the tube held *horizontally* it is clear that the 10-gram *weight* cannot support the 200-gram *weight*. As in the Atwood machine, there is motion in the direction of the greater force. But the 10-gram weight *can* support the 200-gram weight! Simply hold the glass tube vertically in one hand and by a conical motion of the wrist impart an angular velocity to the small mass. At a critical ω and r equilibrium exists so that we may equate Mg to $m\omega^2r$. If, now, a small knot (of colored thread say, to make it visible) is tied to the string so that a fixed r is maintained, and f is clocked by a timer, a quantitative confirmation of the equation can be gotten. Less than 1% experimental error is possible.

II. With equilibrium established grasp the lower portion of the string (or the freely-hanging M) and pull *down*. It is at once noted that the *decrease* in r gives rise to a rapid growth in ω. This is to be expected on the principle of momentum conservation (angular or linear) so that $I_1\omega_1=I_2\omega_2$. (This is true, of course, only if no external torques are imposed, which is the case here since the pull on the string is transmitted to the mass *m along the string*.)

If, for example, r is reduced to $r/2$, $I_2=I_1/4$, so that $\omega_2=4\omega_1$. But now another inquiry raises an apparent dilemma. Let us inquire into the *energy* of the system. At angular velocity ω_1 on radius r_1 the kinetic energy of rotation is $\frac{1}{2}I_1\omega_1^2=\frac{1}{2}mr_1^2\omega_1^2$. At $r/2$ the energy of rotation is $\frac{1}{2}I_2\omega_2^2=\frac{1}{2}mr_1^2/4\cdot16\omega_1^2=2mr_1^2\omega_1^2$. *This is four times the original energy! Where did we get it?* The answer to this is an excellent exercise for beginners and it is not unusual for those who are not beginners to be troubled!

If you wish a thing well done do it yourself.
—LONGFELLOW

LEARNING TO SOLVE PROBLEMS INTELLIGENTLY

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DEFINITION OF A PROBLEM

A distinction is made in mathematics between an *example* and a *problem*. An example denotes a mathematical situation wherein the necessary operation (or operations) for its solution are indicated. A problem, on the other hand, denotes a mathematical situation wherein the necessary operation (or operations) for its solution must be determined. This definition of a problem depends upon what is meant by a mathematical *situation*, a *solution*, and an *operation*. If we confine our attention to arithmetical problems, then the term operation refers to one of the four fundamental operations, namely, addition, subtraction, multiplication and division. In this case the mathematical situation may be defined as a stated relationship (or relationships) between two or more quantities (numbers). The solution of a problem consists of the determination of the quantity (or quantities) whose value is not given in the problem. This quantity is called the unknown quantity, or the required quantity.

We may take for a working definition of a problem the following:

1. A mathematical problem is a stated mathematical relationship between two or more quantities in which the value of one (or more than one) quantity is to be determined in terms of the values of the other quantity (or quantities).

MATHEMATICAL AND LIFE PROBLEMS

During his life time a person encounters many problems, not necessarily mathematical, the solutions of which affect his happiness, income, physical and social status. Unfortunately, many of them are complicated problems. Many of them are not even formulated or stated, and hence do not yield readily to an analysis. In many of them we do not know what the involved factors (quantities) are, whether they are variable factors or constant. Furthermore, the relationship between the factors is either unknown, or extremely difficult to determine. In these "life" problems, often, there is no known method of procedure (operation) to use in order to obtain a solution. In many of them we do not know whether there is a solution or not, and if there is one, we do not know its nature, so that after it is obtained we can not be sure that it is a solution. The situation may be described as follows:

a. We seek the solution of a problem.

b. The problem must be formulated or stated in terms of its elements (factors).
c. These elements (factors) must be identified, and if possible determined.
d. A method of procedure cannot always be found. Often the method of "trial and error" is used.
e. The nature of the solution is not known before hand.
f. After a solution is obtained, we are not sure whether or not it is the correct solution. A check is not possible.

Contrast this situation of a "life" problem with a mathematical problem. Here we may describe the situation as follows:

a. We seek the solution of a problem.
b. The problem is stated either explicitly or implicitly in terms of its elements, that is, the relationship between the quantities is known.
c. The quantities are known, or are readily determined.
d. The method of procedure can always be found. That is, the necessary operation or operations are readily determined.
e. The nature of the solution is known before hand, and can be estimated.
f. The solution can always be checked to determine whether or not it is a correct solution.

Purposes of Problems

The above comparison clearly shows that the ability to solve mathematical problems is transferable to non-mathematical problems, since the situations are similar. A given problem in the life of an individual must either be solved or remain unsolved. If a solution is sought, either the individual must obtain it himself, or pay some one else to furnish him with a solution. In either case an intelligent attitude toward problems enables the individual to deal with them intelligently. This attitude can and should be developed in mathematics courses.

The following definite instructional aims of problem solving should be kept in mind by the teacher.

Reading

The statement of a problem must be understood. This involves ability to read mathematical literature. Terms and phrases used in the statement of the problem must be understood. The child understands the statement of a problem when he can state it in his own words from memory.

Relationship

The study of relationships between quantities is of primary im-

portance in mathematics and elsewhere. However, we cannot take for granted that the child will see a quantitative relationship in a problem. This ability must be developed. The ability to see a quantitative relationship involves the identification of the quantities, and the determination of the nature of the relationship.

In arithmetic there are only two type-relationships used. They may be stated symbolically as follows:

2. Addition—subtraction type:

$$A+B=C.$$

3. Multiplication—division type:

$$AB=C.$$

The following requirements are imposed upon the nature of the quantities A, B, and C in both type-relationships.

4. *If A and B are abstract numbers, then C is an abstract number both in addition—subtraction type, and in multiplication—division type.*
5. *If A and B are denominate numbers expressed in the same unit, then C is a denominate number expressed in the same unit. This applies to the addition—subtraction type only.*
6. *If either A or B is abstract and the other is a denominate number, then C is a denominate number expressed in the same unit. This applies to the multiplication—division type only.*

Operations

The identification of the relationship in a problem enables the child to determine the operation needed to obtain a solution. The child should be able to associate the operation with the type relationship. Expressed symbolically, the operations are:

7. *Addition:*

$$A+B=C$$

where C denotes the *sum*, the *total amount*, etc.

8. *Subtraction:*

$$C-B=A; \qquad C-A=B,$$

where either A or B denotes *remainder*, *difference*, *gain*, *loss*, etc.

9. *Multiplication:*

$$AB=C,$$

where C denotes *product*, *cost*, *distance*, etc.

10. *Division:*

$$AB=C,$$

where either A or B denotes *quotient, price, rate, time,* etc.

If the selection of the necessary operation in the solution of a problem is taught in terms of type-relationships, the child will proceed intelligently. There is no justification for an attitude, or rather confusion, on the part of the child such as: "I don't know when to add and when to subtract." His confession is an indictment that he has not been taught problem-solving.

Solution

The term solution is used in two different ways in mathematics. It signifies the *answer* to the problem. It also signifies the *process* of finding the answer. In most texts solution means the process of finding the answer. The steps in the solution, namely, *estimating, computing* and *checking* the answer are considered separately later on.

Analysis of Problems

Modern texts in mathematics seek to present problem situations that have the following characteristics.

a. Real situations.
b. Familiar situations.
c. Consistent situations.
d. Understandable situations.

Real situations are those which actually occur in real life, whether in school, at home, in the store, or the office. Many hypothetical situations, which were formerly used in textbooks, have been altogether eliminated.

Familiar situations are those with which the child is already familiar or is apt to be. Problems based on the experiences of the child, or the experiences of others about him, present such familiar situations.

Consistent situations are true situations. For example, problems dealing with transportation, though presenting real and familiar situations, must in addition be consistent with known facts. A rate of 25 miles per hour for an airplane is not a consistent situation.

Understandable situations are stated in the language of the child. This does not mean that new terms, whose meaning can easily be looked up, must not be introduced. But it does mean that it is possible for the child to read the problem once or twice and be able to state it in his own language.

Given a problem of the type described above, and given a normal child, problem-solving can be made an intelligent procedure. This

requires two distinct ideas, which may be described briefly as *analysis*, and *manipulation*.

The analysis involves the following steps which will be considered separately.

a. Understanding the statement of the problem.
b. Finding what is required.
c. Finding what facts are given.
d. Deciding what operation or operations are needed.

The manipulation involves the following steps which will be considered separately.

e. Estimating the answer.
f. Computing the answer.
g. Checking the answer.

Estimation may also be considered as a step in the analysis of the problem.

The Statement of a Problem

The understanding of the statement of a problem depends upon two things; ability to read, and familiarity with the relationship upon which the problem is based. The child is able to read the problem if he can explain what the problem means. If there has been any previous inhibition in the development of reading habits, it can be diagnosed here. The teacher who stresses the importance of reading in mathematics renders the child a special service, for correct reading habits are essential not only in mathematics but elsewhere. Then too, reading mathematics is different from ordinary reading. We cannot altogether avoid the usage of technical terms peculiar to mathematics. The meaning of such terms must be understood.

The relationship upon which the problem is based should be a situation with which the normal child at his age is familiar or should be familiar. Care should be taken to present only such relationships in problems. However, a new relationship, or one which the child has forgotten, should be recalled and explained.

The relationship of the problem should be written as a part of the analysis of the problem. It should be written in an abbreviated form, free of numbers. Then it is an easy step to introduce appropriate letters for the words, and express the relationship as a formula. Let the child remember that

11. *A formula is a symbolic statement of a relationship.*

Finding What is Required

The abbreviated statement of the relationship either in words, or as a formula strips the problem of unessential words and phrases. Each letter (or word for which it stands) represents a quantity. The

equality sign represents the verb of the problem, namely, *is*, *gives*, *results*, etc. The operation sign ($+$, $-$, $\times$, $\div$) identifies the type-relationship, discussed above. All that remains is to associate the numbers given in the problem, with the quantities of the relationship. These numbers are the *facts* or the *data* of the problem.

The quantity about which a question is asked, or for which no number is furnished, is the ***required*** quantity. The child should write this required quantity as a step in the analysis in the form:

Required: The cost (or $C=?$).

Finding What Facts Are Given

If the child is able to associate the numerical facts of the problem with the quantities of the relationship, he determines at once what facts are given, or are furnished by the problem. He should write, these facts in the form;

Given: Number of yards $=7\frac{1}{2}$ (or $n=7\frac{1}{2}$)
Price per yard $=1.25$ (or $p=1.25$)

Deciding What Operations Are Needed

If the problem is based upon a single situation, only one operation is needed. The needed operation is either that shown in the statement of the problem, or its inverse. Thus, let the statement of the problem symbolically be

$$A+B=C.$$

To find C, the operation of addition is needed. To find either A or B, the operation of subtraction (the inverse of addition) is needed.

If the problem is based upon more than one situation, each situation should be taught as a separate one—operation problem.

Solution of the Problem

If a careful analysis of the problem has been made, the child knows what he is to do, and how to do it. The analysis furnishes a program, the solution is the carrying out of that program. Since ability to determine whether or not the answer obtained is correct is essentially a part of the solution the child should be taught the three steps of the solution: namely, estimation, computation, and checking.

Estimation

The child must not depend upon the answer furnished by the text, or the teacher, to check his results. That is not done for him in life problems. Yet after he has gone to all the trouble of solving a problem, he should be reasonably sure that his result is accurate. Estimation, and checking serve that assurance.

The indicated operation or operations in the solution of a problem have reduced it to an example, in which he is now told what to do. In the manipulation of the indicated operation he may make a mistake. If he has estimated the answer, any mistake in the operation will be at once detected.

Moreover, as pointed out elsewhere, the habit of estimating approximate results is desirable in itself and should be cultivated. Approximate results, easily (i.e. mentally) obtained give us an understanding and appreciation of the quantitative world about us. Estimation also has its practical uses. If repairs are to be made on the house, the thrifty person asks for an estimate before awarding the contract. The estimate enables him to decide whether or not he can afford the repairs. He can also compare several estimates and accept the most economical one.

Computation

The necessary arithmetical operations with integers, fractions, decimals and per cents have been learned. In computation the child should aim toward *accuracy* and *speed*. If reteaching or drill is needed in individual cases, the teacher can assign the recall drills presented in the text.

Checking

In checking a problem the child substitutes the answer in the statement of the problem. Checking should be considered as a part of the solution of the problem. Estimation has given an approximation to the answer. Checking furnishes an exact proof.

Checking is an essential part of applied arithmetic, that is, the arithmetic of the commercial and industrial world. The child must be taught and must acquire the habit of accuracy. Later on in the world of practical affairs he will find that in his arithmetical computation one hundred per cent accuracy is demanded. Others may not be interested in his methods, or even in his speed, but only in his results. His results must be acceptable, and that means, they must be accurate. Checking should be taught in our mathematics classes as a desirable habit.

Window Attachments are designed to eliminate sash cords and weights. Fitted to the sash, the metal devices permit the removal of the entire window for washing. The kit includes four units plus two zinc strips for covering the pulley openings and a sash plug.

Bath Head Rest is made of quilted rubber and filled with shredded latex. Hair is kept dry while bathing and reading in the bathtub is made easier. The head rest is held in place by suction cups.

PERFORMANCE OF TWENTY-TWO COLLEGE STUDENTS ON THE COOPERATIVE PHYSICS TEST—REVISED SERIES FORM X

ROGERS E. RANDALL
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PROBLEM

The purposes of this study were: (1) to determine to what extent students enrolled in the first semester course of general physics, taught by the writer, had mastered subject matter content found in a physics course on the high school level; and (2) how did these students compare with the National percentile ranks and mean score for secondary schools.

PARTICIPATION

The students who participated in this study were sophomores (27.27%), juniors (36.36%), and seniors (36.36%).

The distribution of the students were as follows:

1. Secondary Education major (with emphasis in biology and mathematics)	5
2. Liberal Arts major in biology and chemistry	5
3. Industrial Arts major	5
4. Electronics major	6
5. Horticulture major	1
TOTAL	22

The population of the students represented in this study ranged in age from 19 to 27. Such an age differential is not unexpected in the average college. It should be pointed out that none of these students had had a course in physics prior to this enrollment. These students were selected randomly from a population of 80 students.

METHOD AND PROCEDURE

The Cooperative Physics Test (High School) was administered to 19 male and 3 female students. This test was selected in order to get a preview of the status of the entire class at the beginning of the course in order that instruction could intelligently be modified to commensurate with the students' empirical needs. The students had fifty minutes to complete the test. All tests were given and scored by the writer according to the directions specified in the format.

RESULTS

Scaled scores on the Cooperative Physics Test for the entire group, both male and female students, ranged from 24 to 50—a range of inferior to average.

Table I shows the frequency distribution of scores, mean score, standard deviations, and *t*-ratio.

TABLE I

DISTRIBUTION OF SCORES, MEAN SCORES, STANDARD DEVIATIONS, AND t-RATIO

Scaled Scores	Frequency	Per Cent
48–50	4	18.18
42–47	3	13.63
29–41	7	31.81
24–28	8	36.36
TOTAL	22	100

Legend:

Mean Score of Group	35.6		S.D.	9.6
Mean Score (National)*	49.9		S.D.	8.8
$t_{obtained}$-Ratio	.05	1.4875†		

* 49.9 is the mean score for 10th grade students with 1 year of study in public secondary schools of the South (11th grade system).

8.8 is the S.D. for public secondary schools of the South.

† The value obtained for the t-ratio was not significant at the five per cent level of confidence.

Table II shows a comparison of the percentile rank between the national population group and the students comprising this study.

TABLE II

COMPARISON OF PERCENTILES

Percentile Ranks	Scaled Score	Students in Study	
		Number	Per Cent
99	70	0	0
87–98	60–68	0	0
50	50	4	18.18
13–41	40–48	4	18.18
1–9	30–38	6	27.27
0	20–28	8	36.36
TOTAL		22	100

ANALYSIS OF DATA

Table I shows that 68.17% of the students made scaled scores within the range of 24 to 41, and 31.81% made scaled scores ranging from 42 to 50.

The mean score (35.6) was considerably less than the National

mean score (49.9) for the South.

Table II shows that none of the students attained a percentile rank higher than 50. 36.36% of the students fell within the percentile rank of 13 to 50. Greater than $\frac{1}{3}$ of the students fell below the percentile rank.

Conclusions and Recommendations

From the scores and percentile ranks of the students participating in this study, it would appear that a strong lecture-demonstration and laboratory course is needed in general physics in order to get the students enrolled in the course at least to the desired National academic level of high school students in the standardization population.

On the basis of the data shown in this study, it appears that students will show a deficiency in college physics.

Based on the limitations of this investigation, the following recommendations are advanced:

1. That more high schools in the locality that serve our students offer a course in physics.

As a corollary to this assumption it would appear that a physical science course designed for general education be included in the freshman year of the college or university as a means of making an attempt to bridge the present academic gap between high school and college training in the physical sciences.

2. That the colleges and universities make a concerted effort to train students who are resourceful and adequately grounded in physics.

BLAMES HEAVY SMOKING FOR THROAT AILMENTS

Smoking excessively over a long period of time was blamed for chronic irritation of the breathing tract, degeneration of the vocal cords and leukoplakia, a disease marked by small white bumps on the lining of mouth and throat.

The blame came in a report by Dr. Linden J. Wallner of Rush Medical School, Chicago, at the meeting of the International College of Surgeons.

"Since the serious diseases do not occur in a high percentage of smokers, it may be argued that we are not justified in urging universal curtailment of smoking, a habit which seems to bring satisfaction to millions," Dr. Wallner said.

"We do have strong evidence that smoking may cause the symptoms and diseases described. When a patient complains of cough, hoarseness, burning or post nasal discharge or presents evidence of chronic inflammation, or leukoplakia, we should urge curtailment of smoking rather than rely on gargles, sprays or antibiotics."

Paper Wrap coated with a plastic polyethylene keeps rosebush roots moist and healthy during shipping or storage. The wrap, which holds the essential dampness in the package, can be folded easily around the plant roots and tied with string. The wrap is available in sheets or rolls.

DEMAND FOR TEACHERS IN SCIENCE AND RELATED FIELDS*

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During the depression, the existence of a teacher vacancy in the science or mathematics fields was regarded as a certain invitation for dozens of applications from many sources. The related fields of engineering and scientific technology were equally overcrowded.

The situation of these workers in our society was aptly described by the well-known phrase, characterizing these people as "a dime a dozen." Today, this has changed and in discussing the current demand for teachers in science and related fields, we will consider primarily three questions: 1. Why the teacher shortage in general? 2. What is the situation in regard to teachers in science and related fields? 3. What solutions can be envisioned?

1. WHY THE TEACHER SHORTAGE?

In Illinois, when a child is born, we do not ask, "Is it a boy?" or "Is it a girl?" but "Where is it going to school?" and "Who is going to teach this child?" This question is particularly apt when applied to the young people in many of our rural high schools where the opportunities to pursue the sciences and advanced mathematics too often do not exist.

To understand the teacher shortage, it is necessary to take a look at resident live birth statistics for the past twenty-two years. In 1933 Illinois gave birth to 112,000 babies, which number increased to 225,000 by 1955. In the United States the year 1933 witnessed the birth of 2.3 million young Americans; whereas this number in 1954 had increased to 4.076 million. Translated to general population, these birth statistics have resulted in a gross national population which is currently estimated at 167 million. In five years it will grow to 178 million, in ten years to 190 million, and in 20 years, 1975, to an estimated 221 million.

Relating this increase to school population, we find that a projection of the Illinois school population indicates an increase from last year's 1,327,000 to 1,659,000 in 1960–61, an increase of 25.1% during a six-year period. For the entire country, the following comparison is rather striking. In 1944, the public schools of America enrolled 23 million children. During the current year this rose to 32 million, while in 1964, the projected enrollment for the public schools of America will total 47.5 million, an increase of more than 100% in

* Presented to The Illinois State Academy of Science, Springfield, Illinois, May 4, 1956.

20 years. Coupled with this huge increase in public school enrollment, we find that the college age group or the people from 18–24 years of age in our population has steadily declined through recent years to a low in 1955 which shows a slight increase in 1956 and which will approximately double by 1975, 20 years hence. The first increase during the past 6 years in the annual supply of new teachers in America will come in 1955–56, an increase, however, which is far too small to match the rapid rise in school population.

The overall picture of supply and demand indicates, in Illinois, an annual need for the next 5 years of approximately 6800 teachers compared with a group of bachelor's graduates in teacher education of 4500 of whom experience reveals that approximately 2250 will be entering the classrooms of Illinois the next fall. In other words, we have in prospect approximately one-third as many graduates as the number of new teachers who will be needed for the classrooms of Illinois. In the country at large, the situation is perhaps equally bad. A recent study by the Ford Foundation reveals a ten-year need for elementary, high school, and college teachers, totalling 1.9 million. Since the anticipated total of graduations from the higher institutions of learning is approximately 3.7 million during this ten-year period, it would require 52% of all the graduates in order to meet the need for teachers on various levels. Comparing this 52% figure with the 20% of our higher education students who were engaged in preparing to teach in 1947, which had risen to 30% in 1955, we find that it is still far from the 52% necessary according to the Ford Foundation estimate.

In answer to our first question "Why the teacher shortage?" I believe we can sum it all up in the fact that there has been a terrific increase in birth rate accompanied by a lessening number of potential new teachers graduating from the schools for teacher education. This combination of events constitutes one of the outstanding educational problems of our time.

2. What is the Situation in Regard to Teachers in Science and Related Fields?

It is accurate to state that an alarming shortage of increasing magnitude exists among the teachers of science and related fields, particularly mathematics. From data supplied by Ray Maul, Associate Director of Research for the National Education Association, we have calculated an index of demand for teachers in the twenty-one major fields studied by Maul. The index is a quotient expressed as a per cent in which the numerator is the number of new teachers

employed and the denominator is the number of new teachers prepared in the colleges and universities for the same teaching field. Returns have been obtained for 29 states and three territories. The results just calculated from these data for 1955 indicate that the demand for general science teachers is third highest among the 21 teaching fields. Physics ranks next, in fourth position, mathematics —fifth, chemistry—eighth, and biological science—eighteenth. The indexes in these five fields have risen during the period from 1950 to 1955 as follows: General Science from 80 to 208 points, physics from 36 to 201 points, mathematics from 72 to 183 points, chemistry from 32 to 111 points, and biological science from 32 to 68 points. These data reflect an increased demand in the face of a decreased supply of the teachers in science and mathematics which is exceeded only in the case of elementary and library science teachers.

At this point a few words are in order as to the supply of science teachers. Using an estimate for 1956 that has proved highly accurate in past years, Mr. Maul states that the total of all high school science teachers graduated annually in the United States shows a decline from 9,096 in 1950 to 4,434 in 1956, a decrease of 51.3%. In the case of mathematics teachers prepared in the colleges and universities, a similar decline is observable, from 4618 in 1950 to 2600 in 1956, a 43.7% decrease. These per cents of decrease may be compared with an overall decline in new high school teachers prepared of 34%, while the elementary teachers graduating from college and universities of America have increased by 35%.

There is, however, a note of optimism in the estimate of 1956 which represents an increase over 1955 for teachers prepared in each of the science and mathematics fields as follows: General science—an increase of 19%, physics—21%, mathematics—21%, chemistry—12%, and biology—an increase of 19%. With the exception of chemistry, all of these fields have increased more rapidly than the average of all high school teachers combined, where an increase of 15.4% occurred. Of course, it must be remembered that these increases in science and mathematics teachers graduating from the colleges and universities will be partly offset by the intense competition for their services from industry and business which are eagerly in search of them.

In conclusion, it must be stated that the past five years have witnessed sharply increasing indexes of demand in the fields of science and mathematics. For 1956, we predict the first upturn for six years in the supply of these types of teachers. However, it is almost certain that this upturn will not match the upturn of public and private school enrollment combined with the increased demand of industry and business for the services of these young Americans.

3. What Solution Can Be Envisioned?

While it is very likely that no single or simple solution can be found for the acute shortage of teachers in the fields of science and mathematics, the following are presented as hopeful possibilities.

1. *Science days* such as those which are sponsored by the Academy of Science in interesting the youth in scientific pursuits and in the teaching of science.

2. *The Future Teachers of America*, an organization which functions both in the high schools and on the campuses of teacher education institutions, to attract young people to the profession of teaching.

3. *Increased facilities for teacher education.* During the past two years Northern Illinois State College has, along with the other state colleges in Illinois, increased its enrollment in teacher education by 43%. The enrollment increase of the past year, amounting to approximately 700 students, was matched almost exactly by the increase of campus housing facilities made available to students. Society must recognize the need for increasing teacher education facilities along with the vastly increasing public school and private school facilities.

4. *Government grants as well as foundation grants* are being made available for the purpose of studying the supply of teachers in the critical area of science and mathematics, and also for the purpose of devising means for improving this supply.

5. Finally, we are getting around to the point of using our Yankee ingenuity in preparing to *adjust to some unavoidable shortages* which are certain to face our schools and colleges in the years to come. Along this line we have learned that 68 television projects involving classroom instruction are in operation the country-over. These projects enable the teacher to serve a much larger audience than the single classroom. Time alone will tell whether this effort will prove successful in the main.

Another device for adjusting to a decreasing teacher supply is the idea of sharing a specialized teacher with several small schools rather than asking this individual to teach one course in physics, let us say, and additional courses in other areas. This may necessitate a travel circuit for the physics teacher such as we have witnessed for music teachers and other specialized teachers in the past.

Another accommodation to the teacher shortage lies in the use of teacher aids, non-certificated personnel of various types who may expedite the teaching process. While much remains to be learned about the effectiveness of this type of activity, it is certainly possible that employed aids as well as volunteer aids such as students, parents, and community-minded individuals may prove to be very helpful to the educative process as the teacher supply dwindles in relation to demand.

Conclusion

In conclusion, we have briefly discussed the reasons for teacher shortage, we have attempted to give some relevant data in regard to the shortage of science and mathematics teachers and finally, we have proposed some solutions to this problem.

We will close with a quotation from President Eisenhower at a recent Golden Key Dinner in which he summarizes the extreme importance of this question we are discussing to the children, the schools, and the very future of America. I quote:

"Truly, teachers are the key to tomorrow. The teacher's task is to guide, and to inspire, and to care what happens to 31 million school children in classrooms all over the land—youngsters who will be in a short span of time the doctors, and master craftsmen, and scientists, and law makers, and leaders in every area of American life. I am confident the day will soon come when because of the efforts of teachers and citizens, every American child will be assured of one of his basic heritages, the finest education that American resources and American wisdom can provide him."

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RADAR METER CATCHES ONLY SPEED VIOLATORS

Speeders may soon be caught by a radar set that spots violators only.

The device can be pre-set from 25 miles per hour to any limit. It then only registers the speed of vehicles, passing in either direction, that are exceeding the limit.

A camera can be attached to the radar set to record on film the car's license number and the speed reading on the meter. By the same token, a tape recorder can be attached to the device to record the speed reading and traffic officer's verbal description of the car, driver and license number.

The meter can also be synchronized with a remote portable traffic light set to stop a speeding car.

The new radar traffic aid was developed by Admiral Corporation.

A TEACHER'S VIEW OF MATHEMATICS*

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What are we trying to do when we teach arithmetic in the primary grades? Simply condition a few unthinking responses as Pavlov did for his dog? I assume that most of you have read of Pavlov's work in regularly serving food to his dog immediately after ringing a bell, until the dog's salivary glands were stimulated simply by the ringing of the bell even though no food was brought in. Are we looking for such automatic responses in arithmetic? Although there are times when a few automatic responses would be welcome, I do not think that such are our goal. Our use of numerous pictures in which groups of girls are compared with groups of doll carriages, groups of children with groups of chairs at a table, and so forth are intended to develop the child's recognition of a common number property of sets which can be matched in a one-to-one manner—students with chairs, husbands with wives, automobiles on a highway with drivers, and so forth. First a child recognizes when one set is the same, more, or less than another. Later he abstracts a number property of a set of elements and identifies this property by a word or symbol as in the case of five fingers on his right hand or 75 people in a room.

Children start their number concepts by abstracting properties of sets of objects. We must stimulate them to continue thinking of mathematics as a study of properties abstracted from the world in which we live. Mathematics as a mass of memorized facts is deadly; mathematics as a study of systems of symbols capable of representing important properties of the physical universe can be a vibrant and living subject.

Many elementary school teachers do an excellent job of emphasizing the ways in which positive integers and arithmetic operations represent physical situations. In secondary school we tend to cut away this dependence upon sets of physical objects and leave things suspended in mid air. Unfortunately many students feel very soon that they are simply drifting in a dense cloud with no sense of up or down and no particular goals in sight except to get out of this mess. When an infant's umbilical cord is cut, other sources of nourishment must be found. When we cut away the pupil's reliance upon manipulations of sets of objects, we must produce other foundations for his work. These new foundations are composed of definitions and assumptions (postulates) based upon the arithmetic experiences in

* Prepared for presentation as part of a panel on "The Classroom Teacher—Keystone in the Mathematics Program" at the annual meeting of the New Jersey Association of Teachers of Mathematics, May 5, 1956 at Rutgers University, New Brunswick, N. J.

elementary school. We are taking another step in our abstraction of number properties. We are developing systems of number symbols and procedures for combining number symbols. The development and use of such systems is one of the major aims of mathematics. Consider as examples of such systems:

the set of positive integers,
the set of positive rational numbers,
the set of all rational numbers (positive, negative, and zero),
the set of real numbers,
the set of complex numbers,
the algebra of real variables and numbers,
the geometry of points and lines on a plane,
the geometry of points, lines and planes in space.

Each of these sets of elements and the operations with them have many very practical interpretations in our physical universe. There are also other mathematical systems including some that are so abstract that no applications for them have been found to date.

Mathematical systems are obtained by abstracting properties of sets of elements, by extending and generalizing other systems as in the gradual expansion of the students concept of number from positive integers to positive rational numbers, to rational numbers (positive, negative, and zero) to real numbers, and, near the end of his high school career, to complex numbers. These systems are abstract systems because of their removal from a strict dependance upon sets of objects and yet it is only in this way that they gain their usefulness. It is bad enough to have different types of units for measures of distances, areas, volumes, angles, weights, time, and so forth. Thank goodness we can use the same arithmetic in each of these cases. Our arithmetic is useful because of the many interpretations and representations that may be used.

Not long ago I visualized our task as teachers of mathematics to be the development of mathematical systems that may be used to represent the various quantitative aspects of our physical universe. I still think that such a goal is a very noble one and a useful guide in seeing beyond a dismal day drilling on fractions to a reasonable understanding of "What is the use of it all?" Fractions represent rational numbers. Rational numbers and operations upon rational numbers may be interpreted in a very wide variety of ways including the basic problems of sharing equally at the primary grade level, the measurements for recipes and also for druggists, prescriptions, and simple ratios. These and many other interpretations can only be understood by understanding fractions. The same understanding is a part of the training of the pilot of a jet airplane and the engineers who design the plane. The range of applications of many topics of

secondary school mathematics is unbounded. As teachers of mathematics we need to look up from our preoccupation with details to glimpse the immensity and the brilliance of the superstructure which rests upon our work, and to find in this superstructure the courage and the inspiration for renewing the vigor of our attack upon our daily problems.

This requires us to develop a perspective for appraising the significance of various aspects of our work. We need to see how the future of mathematics and the future of our pupils in this scientific world depends upon the concepts that we are teaching. We need to see how nearly all mathematical concepts arise as abstractions, generalizations, and applications of arithmetic concepts similar to those underlying our work. We need to seek points of view which will help our better students develop creative methods of thinking in mathematics.

Certainly these goals would keep any of us from becoming complacent and yet another aspect of mathematics is needed to complete the picture. Mathematics is changing. During the life-time of the youngest person here there has been more new mathematics than in all previous recorded history. Modern mathematics is now concerned with all patterns of action, all regularities, all patterns making predictions possible. Some of the predictions such as the number of traffic fatalities on a holiday weekend or the fluctuations of our economy appear far removed from the abstractions of number properties of sets of objects in primary grades. Yet, even though some patterns are currently understood better than others, all of them (whether quantitative or not) are becoming recognized as within the domain of mathematics, within the possible area of application of the methods of study, attack upon problems, and creative thinking that you develop in your classroom.

I hope that these comments will help you to see the significance of your work and the importance of developing in your students a concept of mathematics as a growing body of knowledge composed of numerous systems (including the systems that you are teaching) and having great importance because of the variety of possible interpretations of these systems. Your pupil's future in a steadily increasing number of areas depends upon his understanding of the mathematical concepts of elementary and secondary school. In a very real sense you hold the key to an important part of the future of each of your pupils.

To be trusted is a greater compliment than to be loved.
—GEORGE MACDONALD

WHAT A FIFTH GRADE LEARNS ABOUT ATOMIC ENERGY

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The study of modern science problems in the elementary school is well accepted. The inclusion of a unit on atomic energy has not been so widely accepted. These two facts stimulated the following experimental study.

PROBLEM

What can one fifth grade class in Beloit, Wisconsin, learn about atomic energy?

Procedure

1. The teacher prepared for the task of teaching the unit by studying a variety of background materials concerned with atomic energy.
2. The class consisted of 33 fifth grade pupils from middle class socio-economic backgrounds.
3. The knowledge of atomic energy possessed by these 33 pupils was determined by having them write papers telling all they knew about atomic energy.
4. Reading materials were made available to the pupils. The sources used were: library, booklets from industries, and newspaper and magazine articles.
5. A Professor of Physics from a local college talked to the class and answered questions.
6. Television programs viewed at home were discussed.
7. A filmstrip "Putting Atomic Energy to Work" was shown.
8. At the end of the unit the pupils again wrote papers telling what they knew about atomic energy.

TEACHING METHOD EMPLOYED

1. The pupils were introduced to the unit through the use of a teacher prepared bulletin board.
2. The bulletin board was discussed.
3. The children asked questions. These questions were listed on the chalkboard.
4. The questions were divided into three categories. They are:

A. How is the atom made up?

(1) What is an atom?
(2) What do we mean by atomic energy?
(3) How big is an atom?
(4) What does an atom look like?
(5) What are atoms made of?
(6) Why do we have atomic energy?
(7) Are atoms and atomic energy the same thing?
(8) Is atomic energy radioactive?
(9) Is uranium important in atomic energy?
(10) How can an atom be transported?

B. History of atoms.
(1) Who discovered the atom? When? Where?
(2) What is the history of atoms?
(3) What is the history of atomic energy?
(4) Where does atomic energy come from?
(5) What year did the atomic bomb explode?

C. Uses of atomic energy.
(1) How long will atomic energy last?

(2) What uses are there for atomic energy?
(3) What will it be like in "The Age of the Atom"?
(4) What happens to the atmosphere when the atom bomb explodes?
(5) How destructive is the atom?
(6) How can the U.S.A. be safe if other countries have atomic energy?

5. The pupils read many references searching for the answers to these questions. As they studied they came upon new terms and ques-

tions. What is a chain reaction? What does a neutron do? There were many others.

6. The Professor of Physics was invited to the class to "tell us more about atomic energy."

7. The pupils studied the filmstrip, "Putting Atomic Energy to Work."

8. The pupils gave reports describing the lives and contributions of scientists who worked on atomic energy.

9. Class discussions were held concerning the questions originally stated and those that emerged later.

10. The pupils constructed a piece of apparatus to demonstrate a chain reaction. This was made from mouse traps and corks. (It was a very popular demonstration with all.)

11. The pupils prepared a bulletin board showing the uses of atomic energy.

12. The pupils prepared a chart showing the products of a chain reaction.

Results

The knowledge possessed by the pupils at the beginning was largely concerned with atomic bombs, atomic submarines and other mechanical uses of atomic energy. There were many statements made but these involved only 16 different ideas. No one idea was expressed by all 33 pupils. Many of the ideas appeared in only isolated cases, however, 28 expressed the idea that "atomic bombs exist and are powerful" and 22 made reference to "atomic submarines." The ideas expressed are listed in Table I. It is important to note that all these beliefs or ideas are not accurate. Some pupils seem to have accepted common predictions as existent facts.

Table I

References to Atomic Energy Made by 33 Fifth Grade Pupils Prior to the Study of the Unit on Atomic Energy

Idea	Number of Pupils
Atomic bombs exist and they are powerful	28
Atomic submarines are now in use	22
Atomic energy is a future source of power	13
Airplanes and jets use atomic energy	13
Atomic energy is a powerful force	6
Atomic power requires a small amount of fuel	4
Atomic energy is a new source of energy	2
Rockets can use atomic energy	2
Atomic energy runs automobiles	1
Atomic energy is used by ocean liners	1
Atoms are made of small particles	1
The sun is made of hydrogen atoms	1
Atoms can be split	1
Atoms can be used for peaceful purposes	1
Atoms were thought of about 600 years ago	1
Atoms are made of chemicals	1

After the unit was studied the nature and number of ideas expressed changed. There were 42 different ideas expressed and only three were isolates. Many ideas made reference to the atom as a source of energy. There were 21 who mentioned that atomic energy can be used to cure certain diseases and 17 mentioned the atomic bomb.

TABLE II

REFERENCES TO ATOMIC ENERGY MADE BY 33 FIFTH GRADE PUPILS FOLLOWING THEIR STUDY OF THE UNIT ON ATOMIC ENERGY

Idea	Number of Pupils
A neutron can start a chain reaction when it strikes a certain kind of atom	29
Atoms are made of neutrons, protons and electrons	25
No one has ever seen an atom because of its small size	24
The word "atom" was used by a Greek thinker 2000 years ago	23
Men can diagram atoms	22
Atomic energy can be used to cure certain diseases	21
Submarines use atomic fuel	18
Atomic bombs have been used	17
Everything is made of atoms	16
Electrons revolve around the nucleus in orbits	15
The nucleus is the center of the atom	14
The nucleus is made of neutrons and protons	13
Uranium can fission	13
Agriculture can use radioactive materials to improve crops	13
There are 101 different kinds of atoms	12
Atomic energy is given off when an atom splits	11
Industry makes use of atomic energy	10
Neutrons, electrons, and protons are smaller than the atom	9
A controlled atomic reaction takes place in an atomic pile	7
The atomic theory helps scientists explain why certain things happen	7
Future uses of atomic energy are unlimited	6
Atomic energy is used to preserve foods	6
Einstein studied the atom	5
Alchemists tried to make gold	5
Atoms have an atomic weight	5
An uncontrolled chain reaction is very dangerous	5
Uranium gives off energy when it splits	4
The hydrogen atom has only one proton in its nucleus	3
Scientists do not know what neutrons, protons and electrons are made of	3
Cadmium or graphite can slow down a chain reaction	3
Radium and uranium are naturally radioactive	3
Atoms have an atomic number	3
Atomic rays are harmful to those who work with radioactive materials	3
Lately scientists have studied the inside of the atom	3
Atomic research has been done in Tennessee, Washington, and Illinois	3
Barium and krypton are products of uranium when it fissions	2
The weight lost in fission is changed into energy	2
Various elements can be made radioactive	2
Plutonium is a man made element and is unstable	2
A geiger counter is used to detect radioactivity	1
Atoms can be smashed or fused	1
Madam Curie discovered that uranium was radioactive	1

The ideas expressed after studying the unit indicated a much deeper scientific understanding of atomic energy. "A neutron can start a chain reaction when it strikes a certain kind of atom," was

an idea expressed by 29 pupils. "Atoms are made of neutrons, protons, and electrons" was stated by 25 pupils. The complexity and variety of the ideas expressed are noted from Table II.

It is apparent that the ideas expressed are more accurate as well as more complex.

Conclusions

1. Fifth grade pupils are interested in atomic energy.
2. Boys and girls evidenced equal interest in the unit.
3. There were many differences noted in the nature of the learnings with reference to atomic energy achieved by individual pupils.
4. Fifth grade pupils can learn many things about atomic energy as a result of systematic instruction.

UNVEIL RARE MOSQUITOES AT ARMY MEDICAL CENTER

Thousands of rare mosquitoes were "unveiled" at Walter Reed Army Medical Center here. The mosquitoes, 8,500 live adults and more than 20,000 still in the larval form, were flown here from Malaya.

Following the unveiling ceremony they were installed in quarters in the research laboratory where Army medical scientists hope to learn from the mosquitoes more about how to stop the spread of encephalitis, or so-called sleeping sickness, strange fevers that are like dengue fever, and other unconquered diseases that mosquitoes spread.

The mosquitoes belong to six different species. Two, Culex gelidus and Culex tritaemorhynchus, have never before been successfully colonized or raised in captivity.

The special quarters for the mosquitoes consist of a room paneled in heavy wire screening and cages of heavy wire screen. White mice and baby chicks will be bitten by the mosquitoes, but no human experiments are planned. The mosquitoes are not infected because they were all raised in captivity in Malaya before being flown here.

FILMSTRIP CATALOG FREE

Filmstrip House (347 Madison Avenue, N. Y. 17, N. Y.) announces the release of its new FREE 24-page Catalog 1956–57. Included in the listing of filmstrips for elementary and high school are new sets on elementary mathematics, elementary science, English grammar and composition, and baseball rules.

Among the new Filmstrip House productions are "Learning New Numbers—Fractions," a set of eight color filmstrips by two practicing teachers. These begin with the child's present knowledge in developing the basic concepts and rules necessary to a thorough grasp of the meaning of fractions.

"Whys of Elementary Science, Set I"—four color filmstrips for grades one to four—explain certain simple science phenomena on the level of the young child's experience. These are the first of a science series planned for the lower elementary grades.

Free copies of Catalog 1956–57, giving detailed descriptions and prices of all material, may be obtained on request from Filmstrip House, 347 Madison Avenue, N. Y. 17, N. Y.

EVALUATING ELEMENTARY SCIENCE TEACHING

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The most effective methods for evaluating the outcomes of the teaching of science in the elementary grades are still a matter of conjecture. Various ones have been tried out. A number of others are still in the experimental stage. The difficulty rests in the fact that it is not the minute details of scientific information that students should retain. Rather the mode of evaluation must measure how well pupils organize scientific facts and assimilate the resulting understandings. Also teachers are anxious that pupils *use* the information and understandings to interpret the world in which they live and to solve scientific problems. This requires some way to evaluate the extent to which behavior is influenced through science instruction. Obviously, therefore, such a variety of outcomes will demand many different types of evaluation.

Unfortunately teachers of science in the elementary school tend to stress *what*, *when*, *where*, and *who* questions rather than *how* questions. For example, too often science teaching has emphasized the importance of naming and identifying plants and animals rather than understanding their uses in the world and their relationships to one another. Plants and animals are discussed in terms of what they are like rather than what they do. *How* learning, however, refers to the way facts and events are related to one another—how something causes, or comes from, something else, or how a change in one situation is associated with change in another. *How* learnings refer also to the methods and procedures that are used in solving problems, in getting information and understanding, and in putting these to work in daily life. When the child uses intelligently what he learns, his understandings of science have value. He may, because of his understandings, be able to adapt himself to the changing conditions of his environment. It is said then, that he is learning to solve life's problems.

Elementary teachers do not have either the time or the energy to prepare elaborate measuring instruments. Evaluation procedures must, for most part, be simple ones which can be fitted into the daily round of activities. Teachers must adopt and devise simple methods and instruments of evaluation for their own purposes. First, however, they must have a clear view of the general outcomes they wish to evaluate. Following is a list of some of the more important ones that might be emphasized by the teacher:

1. Children should improve in their ability to attack a problem and come to a satisfactory conclusion in regard to that problem.

2. Children should become more and more responsible in carrying out their plans.
3. Children should grow in their ability to work together.
4. Children should become better able to make use of the materials of science as they work toward the solution of a problem.
5. Children should approach a discussion with an open mind and yet be critical of their own ideas and of the ideas of others.

In addition to these more general outcomes, the specific ones involving scientific understandings must be stated clearly. A few examples that may be suitable in the third grade are these: 1. To know that the air that surrounds us has pressure and can be used to do work for us. 2. To learn some of the ways in which plants scatter their seed. 3. To know that the earth rotates and that this rotation causes day and night. 4. To show that if there were no plants, animals would starve. 5. To know that plants which have green leaves must have light in order to grow. 6. To know how insects survive the winter.

The second step is to determine the types of pupil behavior that are associated with these outcomes. Changes must occur in this area if the outcomes are to be functional.

From here the method of evaluation is chosen. In any type of evaluation it must be kept in mind that pupils cannot be expected to progress at the same rate toward any specific goal that has been established. Growth must be considered an individual matter.

One way is to keep anecdotal records or secure evidence of the degree to which science instruction operates in the lives of boys and girls. This type of evaluation is especially successful in the elementary grades where few tests can be given with any degree of satisfaction. Behavior can be evaluated by the alert teacher who is a constant observer of his pupils behavior and reactions. The following questions may serve as a guide for such observations:

To what extent does the child:

1. Recognize problems or show curiosity about his daily surroundings?
2. Suggest answers or methods of problem solving, rather than use "fairy-tale" answers?
3. Differentiate between the value and reliability of different sources of information?
4. *Use* learning, rather than just *recite* learning?
5. Draw conclusions carefully or jump quickly to conclusions?

To what extent, also, does the child show an increasing appreciation and understanding of such points as these:

1. Natural events, such as thunder and disease, have natural causes.
2. New discoveries and inventions require us to change our ways of living.
3. Science has been developed by people of many nationalities and groups.
4. Scientific knowledge should be used for the good of all people. (The new polio vaccine discovery is a good example.)

Records must be kept of each student and to be meaningful, must be evaluated over long periods of time. An illustration of anecdotal records over a span of time follows:

Early autumn:
Mary found a snake and ran screaming to the schoolhouse. John tried to kill it by throwing stones at it. After the snake had disappeared into the grass Mary and John indicated no further interest or understanding.
The following Spring:
Mary found a snake sunning itself near a rock. She called John to come to see it, they both evidenced curiosity about it, asked what kind it was, what it was doing there, and if they might keep it in the school terrarium.

An alert teacher will recognize such development as a clear indication of wholesome science learning, a change in understandings, actions, and outlooks. Some of these changes may be evident to anyone who knows his pupils intimately. Others can be judged only through carefully planned evaluation or after a period of time. In many cases it seems desirable to devise methods which will yield more immediate, though admittedly less valid, evidence of achievement of the desired outcomes. For example: A child should be able to look at two or more objects and detect similarities and differences. In order to test how much a child has achieved in this particular scientific attitude take him on a carefully planned field trip in which he is to make a comparison of crickets and grasshoppers. Here the child's curosity about his daily surroundings in the nature field can be checked and he has a chance to use learning rather than just recite it. Also he can draw conclusions from his own observations which should give a new meaning to grasshoppers and crickets, rather than to class them as just more bugs to be avoided. The following methods of comparison could be suggested:

1. Compare the protective coloration of crickets and grasshoppers. Have a child put a cricket and a grasshopper on the ground as near together as they will stay. Have another child go ten feet away and see which can be seen more distinctly, the cricket or the grasshopper.
2. Put a grasshopper on a bush. Try to make a cricket stay on the bush. Why won't the cricket stay on the bush?
3. Put a grasshopper and a cricket down some place where the grass is long. Which is easier to catch, the cricket or the grasshopper? Why is it harder to catch the cricket in the grass?
4. Try to make the cricket fly. What is the matter with his wings?
5. Put grasshopper and cricket down together and see which can jump the farther.
6. Listen to the sound made by the grasshopper and cricket and find out how they make them.
7. Compare the jumping legs of the cricket with those of the grasshopper after the children have found that each has jumping legs.

For anecdotal records it is probably better to concentrate on the observation of a few children each day. This will increase the detail and hence the validity of the observations.

In searching for standards against which the responses of children in science discussions may be judged, one should consider possible progress in regard to more discrimination (dealing with more than one idea), more recognition of relatedness of events (more than one idea involved), more desire for proof, more reasons for speculation, more evidence of responsibility, more cooperation, more initiative.

One should also have opportunities for evaluating students in action on original problems in science rather than watching them repeat the experiments performed by scientists in the past. These suggestions may serve as criteria for such evaluation:

Present an experiment or question to which the child does not know the result or answer.

1. Can the child state clearly what the question or problem is?
2. Can he help suggest facts that relate to the problem?
3. Can he suggest possible answers to the problem?
4. When he has selected the most likely answer can he suggest an experiment or a series of obesrvations or reading which may lead to the correct answer?
5. Can he carry out the plans he has selected?
6. Can he evaluate his own work and that of the class by the results of the outcome of his experiments and observations?

Another possibility is the pencil-and-paper test. In general, however, they should be kept to a minimum. Tests must be given (as a requirement of the school), should be devised by the teacher and describe real-life stituations which will appraise the pupils' understanding of the big ideas of science. They should be constructed so that pupils will have to *do* the following kind of things:

Recall information and apply it to new situations.
See relationships between objects and phenomena.
Analyze data and draw appropriate conclusions from them.
Make decisions on the basis of reading material.

A pencil-and-paper test can reveal only how a pupil reacts to a situation that is described. There is no assured relationship between this type of behavior and the way he might react to a real life situation. Within these limitations however the test must be designed to measure, in so far as possible, the attainment of all the objectives and not merely the subject-matter aim.

The multiple choice type of item is probably among the best of the pencil-and-paper variety. The items require much labor and thought to prepare but it is fairly objective and reliable, and reduces guessing to a minimum. There are several precautions to follow in constructing such a test. Not less than four choices are needed for each item; only one choice should be correct; incorrect choices should be plausible; and questions and answers should be arranged in random order.

Example:

The deer and the cow defend themselves with their:

1. hooves
2. teeth
3. claws
4. horns

A simple test of the short-answer type where the child merely has to write a word or a phrase at the end of the sentence may measure fact learning effectively. Examples should be straight-forward and simple, and should deal with the facts themselves, not from obscure phrases.

Examples:

1. As water vapor condenses it gives up (heat).
2. A fire cannot burn without (air).
3. The members of the sun's family are called (planets).

True-false items should deal with direct information, not with remote, complicated, or tricky material. These tests however do tend to promote guessing.

Examples:

T-F 1. If there were no plants animals would still be able to find food.
T-F 2. If warm moist air strikes cold objects or cold air it drops the water that it carries.

Matching items are often poorly constructed. They should be: 1. Relatively short, and 2. all on the same type of material.

The following exercise uses matching properly.

Match the following birds with the characteristic that best describes each one:

	Chief characteristic	Bird
1. _____	clean small twigs of trees.	Chickadees
2. _____	catch insects in the air.	Hawks
3. _____	clean larger limbs.	Owls
4. _____	pick up seeds.	Nuthatches
5. _____	destroy rats and mice by day.	Gulls
6. _____	are garbage cleaners.	Sandpipers
7. _____	clean shallow mud flats	Barn swallow
8. _____	destroy rats and mice by night.	Sparrows

Most teacher-made tests and standardized examinations in science fail to provide much evidence of growth in achievement of objectives in understanding. If one wants to sample understanding of science rather than just factual information, it would be best to devise objective test items, such as the following, for use with upper-grade elementary school children (note that each exercise asks first for a factual answer, then for a big idea).

A boy had a pail full of water. He placed a steel nail and a piece of Balsa wood beside each other on top of the water. What would probably happen? (Circle only one.)

1. The wood sank to the bottom of the pail, and the steel nail floated.
2. The wood and the nail both sank.
3. The wood floated and the steel nail sank.
4. The wood and nail both floated.
5. The nail moved over to the side of the pail and stuck there, and the wood just floated on the water.

Which of the following big ideas of science gives the best explanation of what happened? (Circle only one.)

1. Things made of wood always float, and things made of steel always sink.
2. The pail was magnetic and so it pulled the steel but not the wood.
3. Water is soft, so all things can move easily through it.
4. Steel is heavier and wood is lighter than an equal amount of water, and gravity acts on all matter.
5. Water is composed of two parts of hydrogen and one part of oxygen.
6. On a cold day the water would be frozen, so neither the wood nor the steel would sink.
7. Wood contains air but steel does not.

Evaluation is of little service unless the findings are wisely used. Simple evaluation procedures that fit daily activities are helpful in exploration and planning, in diagnosing difficulties, and in redirecting learning activities, in which *how* learnings are stressed. These procedures are carried on by anecdotal records, original problems, and pencil-and-paper tests describing real-life situations. As a result of these procedures, a record is shown of changes in pupil behavior and individual growth.

HIGHEST MOUNTAINS IN THE UNITED STATES

Mount Rainier is only two feet higher than previously recorded. The new official altitude for the northwestern volcanic cone is 14,410 feet above sea level.

The new measurement was made by scientists of the U.S. Geological Survey. The previously accepted elevation of 14,408 feet was determined by the Survey in 1913.

In June, 1955, a final resurvey of Mount Harvard in Colorado showed that it was actually 21 feet higher than had been recorded. At that time, Mount Rainier was listed as the fourth highest mountain in Continental United States. However, with Mount Harvard recorded at the new height of 14,420 feet it became the third highest and 14,418-foot Mount Massive, also in Colorado, dropped to fourth, dropping Mount Rainier to fifth.

Mount Whitney in Sequoia National Park, California, at 14,495 is the highest and 14,431-foot Mount Elbert in Colorado, second highest.

Plastic Steel for all types of repairs hardens to a rigid steel-like mass in two hours after the addition of a hardening agent. Made of 20% plastic and 80% steel, the mixture bonds itself to aluminum, bronze, brass, iron, wood, glass, concrete and other surfaces.

MEET MR. TAU

JOHN SATTERLY
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1. In calculations made during the study of pentagons, pentagrams and the two regular solids, the icosahedron and (pentagonal) dodecahedron, a certain number continually occurs. It has been named "Tau" and is designated by τ. Its properties are many and curious, as will be seen below.

2. "Tau" is equal to

(1) $2\cos 36^\circ$ or $1/(2\sin 18^\circ)$

(2) $(\sqrt{5}+1)/2$

(3) The positive root of the equation $x^2-x-1=0$

(4) The value of

$$1+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{1+\cdots}}} \quad \text{ad infinitum}$$

or as this is written for brevity

$$1+\frac{1}{1+}\,\frac{1}{1+}\,\frac{1}{1+}\cdots \quad \text{ad infinitum}$$

(5) 1.618033989 · · ·

(6) The ratio, when n is very large, of the $(n+1)$th term to the nth term in the celebrated Fibonacci series

$$0 \quad 1 \quad 1 \quad 2 \quad 3 \quad 5 \quad 8 \quad 13 \quad 21 \quad 34 \quad 55 \cdots$$

where each number after the second is the sum of the two immediately preceding numbers.

(7) The ratio of the larger segment of a straight line to the smaller segment when this line has been divided "In Extreme and Mean Ratio" an operation sometimes called "The Divine Section" or "The Golden Section." Thus if a line of length $x+y$ is divided into two parts x and y so that $(x+y)/x=x/y=r$ say, then $(r+1)/r=r$ and $r^2-r-1=0$ which is the same as (3) above.

3. *Notes*

On 1. Most Trigonometries prove

$$\cos 36^\circ=\tfrac{1}{4}(\sqrt{5}+1).$$

As

$$\sqrt{5}=2.236080 \therefore \cos 36^\circ=0.8090170=\tau/2$$

On 3. If $x^2-x-1=0$ the usual method of solution of a quadratic equation gives

$$x=\frac{+1\pm\sqrt{1+4}}{2}.$$

Therefore

$$\tau=\tfrac{1}{2}(\sqrt{5}+1).$$

We may notice here that since $\tau^2-\tau-1=0$ other equations follow: (1) $\tau^2=\tau+1$, (2) $1=\tau^2-\tau$ and dividing by τ we get $1/\tau=\tau-1$,

$$(3) \qquad 2-\tau=(1-(\tau-1))=1-\frac{1}{\tau}=\frac{\tau-1}{\tau}=\frac{1}{\tau^2}$$

On 4. Derivation of the Continued fraction expression. We have $\tau^2=\tau+1$. Divide by τ, we get

$$\tau=1+\frac{1}{\tau}$$

Substitute for τ in the right hand term and we get

$$\tau=1+\cfrac{1}{1+\cfrac{1}{\tau}}$$

and so on.

On 6. The ratios of any two consecutive numbers in the Fibonacci series are successive convergents to τ. Thus we have

$$\frac{2}{1},\ \frac{3}{2},\ \frac{5}{3},\ \frac{8}{5},\ \frac{13}{8},\ \frac{21}{13}\ \ldots$$

These are alternately $>$ and $<\tau$.

The curious may like to know that

$$10000/9899=1.010203050813213455 9$$

but the resemblance to the Fibonacci numbers appears to go no further.

On 7. Rectangles whose sides are in the ratio of τ to 1 are said to be of the shape most pleasing to the eye; test this on the rectangles which you see around you.

We shall see later how τ enters into the shape of and the calcula-

tions with regard to the Pentagon and its associated plane and solid figures.

4. *Mr. Tau and Algebra.* Table I shows Integral Powers of τ. To read easily start at τ^0 and work down using the all powerful expression $\tau^2=\tau+1$. Then work up from τ through its inverse powers.

TABLE I

. . . .	
$\tau^{-4}=5-3\tau$	$=(7-3\sqrt{5})/2=0.1459$
$\tau^{-3}=2\tau-3$	$=\sqrt{5}-2 \quad =0.2361\cdots$
$\tau^{-2}=2-\tau$	$=(3-\sqrt{5})/2 \quad =0.3820\cdots$
$\tau^{-1}=\tau-1$	$=(\sqrt{5}-1)/2 \quad =0.6180\cdots$
$\tau^0=1$	$=1 \quad =1.0000$
$\tau^1=\tau$	$=(\sqrt{5}+1)/2 \quad =1.6180\cdots$
$\tau^2=\tau+1$	$=(3+\sqrt{5})/2 \quad =2.6180\cdots$
$\tau^3=2\tau+1$	$=2+\sqrt{5} \quad =4.2361$
$\tau^4=3\tau+2$	$=(7+3\sqrt{5})/2=6.8541$
$\tau^5=5\tau+3$	. . . . .
$\tau^6=8\tau+5$	
. . . .	

Each power of τ is the sum of the two immediate expressions above. Note the occurrence of the Fibonacci numbers.

5.

TABLE II

PRODUCTS OF τ AND $(\tau+$INTEGERS$)$

	$\tau^2=\tau\cdot\tau=\tau+1$
Also	$\tau^3=\tau(\tau+1)=2\tau+1$
	$\tau(\tau+2)=3\tau+1$
	$\tau(\tau+3)=4\tau+1$
	. . . . .
Also	$\tau^4=(\tau+1)(\tau+1)=3\tau+2$
	$(\tau+1)(\tau+2)=4\tau+3$
	$(\tau+1)(\tau+3)=5\tau+4$
	. . . . .
Also	$(\tau+2)(\tau+3)=6\tau+7$
	$(\tau+2)(\tau+4)=7\tau+9$
	$(\tau+2)(\tau+5)=8\tau+11$
	. . . . .
Also	$\tau(\tau+1)(\tau+2)=7\tau+4$
	$(\tau+1)(\tau+2)(\tau+3)=19\tau+13$
	. . . . .

6. In the act of working out problems on Pentagons, etc., involving expressions containing τ many simplifications may be made if certain identities containing τ are recognized, remembered and used. Table III gives a list.

TABLE III

IDENTITIES INVOLVING τ

$\tau+2=\tau\sqrt{5}. \quad 2\tau-1=\sqrt{5}. \quad 2\tau+1=\tau^3$

$2-\tau=(\tau-1)/\tau=(\tau-1)^2=1/\tau^2=1/(\tau+1)$

$4\tau+3=(\tau+1)(\tau+2)=\tau^3\sqrt{5}$

$1/(4\tau+3)=(2-\tau)/(\tau+2)=0.1056$

$(3-\tau)(\tau+2)=5$

$(\tau+2)/(3-\tau)=\tau^2$

$\sqrt{(4\tau+3)(3-\tau)}=\sqrt{5+5\tau}=\tau\sqrt{5}=\tau+2$

$\sqrt{4\tau+3}=\tau^{3/2}5^{1/4}=3.0777$

$\sqrt{(4\tau+3)/(\tau+2)}=\tau$

$(4\tau+3)/(3-\tau)=\tau^4=3\tau+2$

$3-\tau=\sqrt{5}/\tau=(\tau+2)/(\tau+1)=(\tau^2+1)/\tau^2=1.3820$

$3-\tau=4-\tau^2=(2+\tau)(2-\tau)$

$(3+\tau)/(3-\tau)=\{(\tau+2)(\tau+3)\}/5=(6\tau+7)/5=3.3416$

$\sqrt{3-\tau}=(5^{1/4})/(\tau^{1/2})=1.1756$

$\tau/\sqrt{3-\tau}=(\tau^{3/2})/5^{1/4})=1.3764$

$\tau\sqrt{3-\tau}=5^{1/4}\tau^{1/2}=1.9021$

$(1-\frac{1}{5})\tau^2)/(2-\tau)=1/3$

7. Answers to problems involving τ often look quite different if obtained by different methods or routes. To guard against this always get rid if possible of any τ-term in the denominator by using a relation in Table III, also reduce the numerator to terms in the first power of τ and numerics by using the relations in Table I. Thus

$$(28\tau+11)/(\tau-1)=(28\tau+11)\tau=28\tau^2+11\tau=39\tau+28$$

$$(10\tau+9)/(3-\tau)=\{(10\tau+9)(\tau+2)\}/5=(10\tau^2+29\tau+18)/5$$
$$=(39\tau+28)/5$$

$$(46\tau+30)/(\tau+2)=\{(46\tau+30)(3-\tau)\}/5=(62\tau+44)/5$$

$$\frac{1}{\tau^4}\,\frac{46\tau+30}{\tau+2}=\frac{62\tau+44}{5}\,(5-3\tau)=\frac{1}{5}\,(34-8\tau)$$

$$\tau^4(17-4\tau)=31\tau+22$$

8. *Mr. Tau and Trigonometry*

The textbooks of Trigonometry give the values of the trigonomet-

rical functions of 36° and 18° in terms of $\sqrt{5}$. Table IV lists these and gives also the values in terms of τ.

TABLE IV

The function	In terms of $\sqrt{5}$	In terms of τ	Numerical value
sin 18°	$\frac{1}{4}(\sqrt{5}-1)$	$\frac{1}{2\tau}$	0.3090
cos 18°	$\frac{1}{4}\sqrt{10+2\sqrt{5}}$	$\frac{1}{2}\sqrt{\tau+2}$	0.9511
tan 18°	$\frac{\sin 18°}{\cos 18°}$	$\frac{\tau-1}{\sqrt{\tau+2}}$	0.3249
sin 36°	$\frac{1}{4}\sqrt{10-2\sqrt{5}}$	$\frac{\sqrt{3-\tau}}{2}$	0.5878
cos 36°	$\frac{1}{4}(\sqrt{5}+1)$	$\frac{\tau}{2}$	0.8090
tan 36°	$\frac{\sin 36°}{\cos 36°}$	$\frac{\sqrt{3-\tau}}{\tau}$	0.7265

9. *Tau in Geometry*

(1) The following (Fig. 1a) shows a simple geometrical construction for the "Divine Section" of a line AB. Make $BC=\frac{1}{2}AB$, $CD=CB$, $AE=AD$. Take BC as unity, then $AC=\sqrt{5}$, $AD=\sqrt{5}-1=AE$, and $EB=3-\sqrt{5}$. Therefore

$$AB/AE=2/(\sqrt{5}-1)=\tfrac{1}{2}(\sqrt{5}+1)=\tau$$

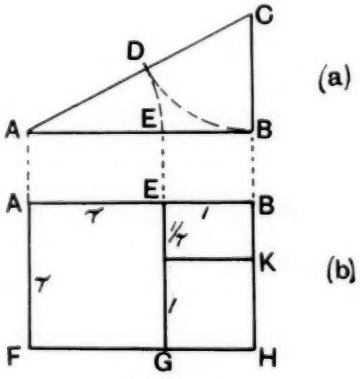


FIG. 1a, b

and $AE/EB=(\sqrt{5}-1)/(3-\sqrt{5})=\frac{1}{2}(\sqrt{5}+1)=\tau$
and $AB/AE=AE/EB$.

(2) *The Aesthetic Rectangle.* $ABHF$ (Fig. 1b) is such a rectangle of sides $AB=\tau+1$, $AF=\tau$.

$$AB/AF=(\tau+1)/\tau=\tau^2/\tau=\tau/1.$$

E is the "divine section" of AB and $AE/EB=\tau/1$. Take the square on AE away from the rectangle. It leaves the rectangle EH of sides $BH=\tau$ and $BE=1$. Therefore rectangle EH is similar to rectangle AH. Take away from rectangle EH the square of GH, and there is left the rectangle EK of sides $BE=1$, $BK=\tau-1=1/\tau$, therefore rectangle EK is similar to the previous rectangles. The ratios of the respective areas are simple.

Rectangle $AH=(\tau+1)\tau=\tau^3$

Square $AG=\tau\times\tau=\tau^2$

Rectangle $EH=1\times\tau=\tau$

Square $GK=1\times1=1$

Rectangle $EK=1\times(\tau-1)=1/\tau$

The process of subdivision may be continued indefinitely, also the converse process of addition. Defining a *gnomon* as that figure which added to a given figure makes a similar figure we see that the squares are gnomons to their respective rectangles. Fig. 2 shows the rectangles on a larger scale with the process of subdivision more advanced. If the original rectangle is not true to shape the smaller figures go far astray. To keep the diagram correct draw the straight lines BF, EH. These are at right angles to each other and intersect at O the

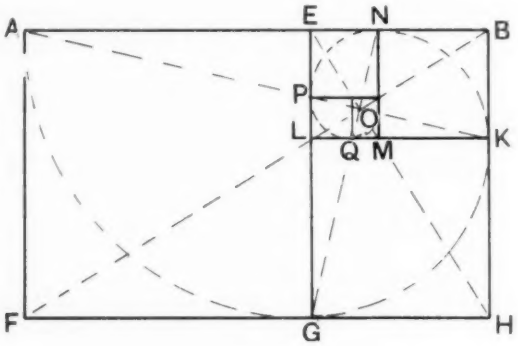


FIG. 2

limit of the ingrowing squares and rectangles. The intersection of BF and EG gives L the starting point of the line LK, the intersection of EH with LK gives M the starting point of MN and so on. If we take an origin at F, axes of x and y along FH, FA the coordinates of O are $\tau^3/\sqrt{5}$, $\tau^2/\sqrt{5}$. Draw also $OA, OG, OK \cdots OG$ is $\perp OA$ and to OK, in fact the region around O is divided into 8 equal angles of 45° each. Calculation shows that

$$OA = \sqrt{\frac{2}{5}(4\tau+3)}, \quad OG = \sqrt{\frac{2}{5}(\tau+2)}, \quad OK = \sqrt{\frac{2}{5}(3-\tau)}$$

so that $OA/OG = \tau = OG/OK = \cdots$. Therefore an *equiangular spiral* may be drawn through $AGKNPQ \cdots$ having its pole at O. The spiral looks as if it were tangential to AF at A, FH at G, HB at K, etc., but it is not quite so.

(3) *The Isosceles Triangle of Vertical Angle 36°* (Fig. 3). Let DAB be such a triangle of base $= a$. Then $DB/\frac{1}{2}AB = 1/\sin 18°$. $\therefore DB = a\tau$. Draw BQ bisecting $\angle DBA$. Then $BQ = AB = a = DQ$, and $AQ = a\tau - a = a(\tau - 1) = a/\tau$. This is the "thrice-isosceles" triangle, and in area

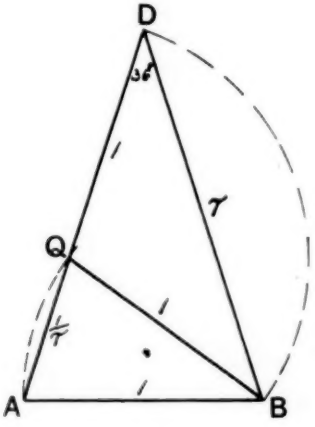


FIG. 3
(Side AB is taken as unity)

$$\Delta ABQ : \Delta QBD : \Delta ABD :: 1 : \tau : \tau^2.$$

The ΔBQD is a gnomon to ΔABQ for added to ΔABQ it makes a similar ΔADB.

(4) *The Pentagon*. $ABCDE$ (Fig. 4) is a regular pentagon of side

$AB=a$. O is the center of the circumcircle and DOP is $\perp AB$. Then it can be shown that

$$OP=\frac{1}{2}\,a/\tan 36^\circ=\frac{1}{2}\,a\,\frac{\tau}{\sqrt{3-\tau}}=0.6882a$$

$$OA=\frac{1}{2}\,a/\sin 36^\circ=a/(\sqrt{3-\tau})=0.8506a$$

$$DA=\frac{1}{2}\,a/\sin 18^\circ=\tau a=1.6180a$$

$$DP=a\sqrt{\tau^2-\frac{1}{4}}=\frac{a}{2}\sqrt{4\tau+3}=1.5388a$$

$$\text{Area of pentagon}=\frac{5}{4}\,a^2\,\frac{\tau}{\sqrt{3-\tau}}=1.7204a^2.$$

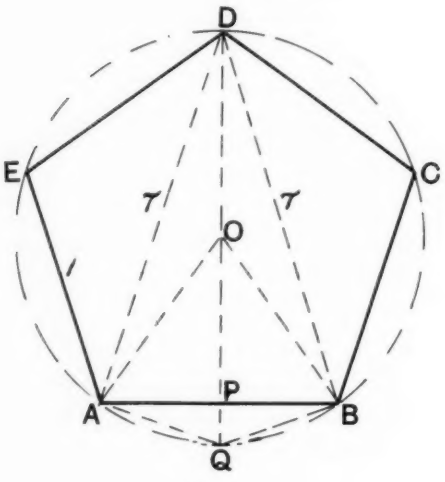


FIG. 4
(Side AB is taken as unity)

Also DA, DB divide the area of the pentagon into three areas $\triangle DEA$, $\triangle DAB$, $\triangle DBC$ whose ratios are

$$\frac{1}{\tau}:1:\frac{1}{\tau}\cdot$$

and

$$\frac{\text{Area of Pentagon}}{\text{Area of }\triangle DAB}=\sqrt{5}=2\tau-1$$

NOTE. If DP is produced to cut the circle in Q, AQ is the side of a regular decagon fitting in the circle and $AQ = 2R \sin 18 = R/\tau$ where $R = OA$. Substituting for R we find that the side of the decagon

$$= a/(\tau\sqrt{3-\tau}) = a/(\sqrt{\tau+2}) = 0.5257a.$$

(5) *The Pentagram* (a so-called mystic figure). The construction is obvious (see Fig. 5). Let $AB = a$. Each star triangle is a mirror image of a triangle in the pentagon, e.g. $\triangle AFB$ is a mirror image in AB of $\triangle ADB$. Slant height of star triangle, e.g. $AF = a\tau$.

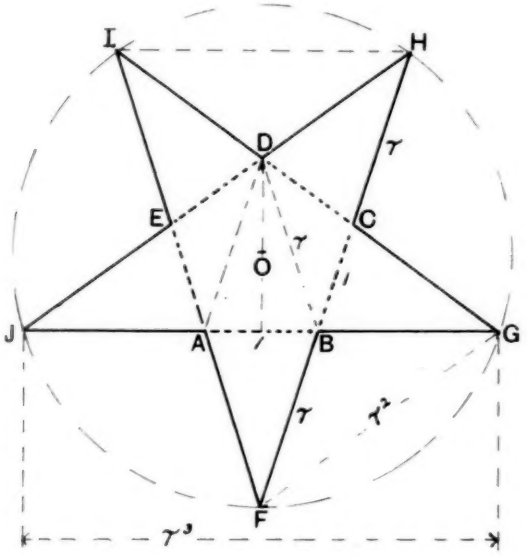


FIG. 5
(The side AB is taken as unity)

Distance between vertices of two adjacent star triangles, e.g. $FG = a\tau^2$. Distance from one vertex of a star triangle to the next but one, e.g.

$$FH = (2\tau+1)a = a\tau^3$$

Area of star triangle eg.

$$\Delta AFB = \frac{a^2}{4}\sqrt{4\tau+3} = 0.7694a^2$$

$$\frac{\text{Area of star } \triangle}{\text{Area of } \triangle AOB} = \left(\frac{a^2}{4}\sqrt{4\tau+3}\right) \Big/ \left(\frac{a^2}{4}\,\frac{\tau}{\sqrt{3-\tau}}\right)$$

$$= \sqrt{(4\tau+3)(3-\tau)}/\tau = \tau\sqrt{5}/\tau = \sqrt{5}.$$

$\therefore$ (Area of Pentagram)/(Area of Pentagon) $= \sqrt{5}+1 = 2\tau$.

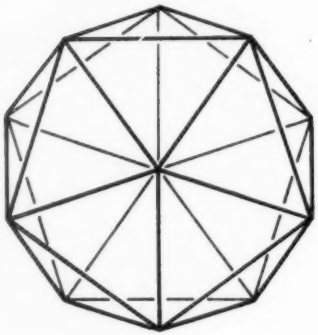
(6) *The Icosahedron.* The surface of the regular icosahedron (Fig. 6a) consists of twenty equal equilateral triangles. If edge $= a$

Radius of circumsphere $= \frac{1}{2}5^{1/4}\tau^{1/2}\cdot a = 0.951a$

Radius of sphere through mid-points of edges $= \frac{1}{2}\tau a = 0.8090a$

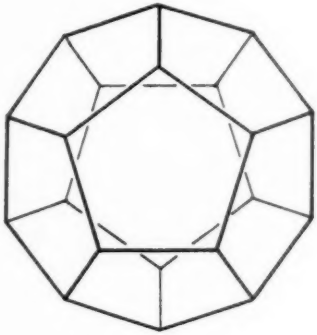
Radius of inscribed sphere $= \dfrac{1}{2\sqrt{3}}\tau^2 a = 0.755a$

The Volume $= \frac{5}{6}\tau^2 a^3 = 2.1817a^3$



(a)

FIG. 6a



(b)

FIG. 6b

(7) *The Dodecahedron.* The surface of the regular (pentagonal) dodecahedron (Fig. 6b) consists of twelve equal regular pentagons.

The radii corresponding to the descriptions above are

$$\frac{\sqrt{3}}{2}\tau a = 1.401a \qquad \tfrac{1}{2}\tau^2 a = 1.309a, \qquad \tfrac{1}{2}5^{-1/4}\tau 5^{1/2}a = 1.114a$$

respectively.

$$\text{The Volume} = \tfrac{1}{3}5^{1/2}\tau^4 a^3 = 7.663a^3$$

The proofs of the above results are not beyond a student's capabilities but they are long.

10. *Mr. Tau's Relations.* We have seen that if we start with the

numbers 0, 1, 1 and add (the last) two at a time we get the Fibonacci numbers and the ratio of two consecutive numbers converges to $1.6180\cdots$, i.e. to τ, and τ is one root of the equation $x^2-x-1=0$. If we take *any* two numbers at the start and add two at a time the ratio of two consecutive numbers also converges upon $1.618\cdots$. For example starting with 1.5 we get

$$1\ 5\ 6\ 11\ 17\ 28\ 45\ 73\ 118\cdots$$

A Fibonaccian will show that this series is the sum of

$$1\times(1\ 1\ 2\ 3\ 5\ 8\ 13\ 21-)$$

and

$$4\times(0\ 1\ 1\ 2\ 3\ 5\ \ 8\ 13-)$$

and this is true (with a different numeric from 4) for all such series so that we still are linked to the Fibonacci series. If we start with any three numbers and add three numbers at a time we get a series having a convergent ratio of $1.839286\cdots$ and this is a root of $x^3-x^2-x-1=0$. Similarly starting with four numbers and five numbers as shown in the table below (Table V).

TABLE V

FIBONACCI AND POST-FIBONACCI SERIES

Start with	Add	Convergent Ratio	A Root of the Equation
Any two numbers	Two at a time	$\tau=1.618\cdots$	$x^2-x-1=0$
Any three numbers	Three at a time	$1.839\cdots$	$x^3-x^2-x-1=0$
Any four numbers	Four at a time	$1.927\cdots$	$x^4-x^3-x^2-x-1=0$
Any five numbers	Five at a time	1.965	$x^5-x^4-x^3-x^2-x-1=0$
Any no. of numbers	All at a time	2.000	$\cdots\cdots\cdots\cdots$
Any two numbers	3×last+2×last but one	3.56	$x^2-3x-2=0$
Any two numbers	3×last−2×last but one	2.00	$x^2-3x+2=0$
Any two numbers	2×last+3×last but one	3.00	$x^2-2x-3=$

Variants are shown in the lower part of the table but we must stop here. Useful reference books are Sir D'Arcy W. Thompson's "Growth and Form" (Cambridge, University Press and Macmillan Company, New York) 2nd edition, 1942, Chs. XI, XIV and H. M. Cundy and A. P. Rollett, "Mathematical Models" (Clarendon Press, Oxford), 1942, Ch. II, but other references are available e.g. H. S. M. Coxeter, "The Golden Section, Phyllotaxis and Wythoff's Game" (*Scripta Mathematica*, New York) Vol. XIX, Nos. 2–3, 1953.

"Good bye, Mr. Tau, we have enjoyed our meeting."

METALS FOR ELECTRONICS

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January 6, 1896, Wm. C. Roentgen, a German, made public his discovery of the X-ray. He did not know he was reporting also a first major application of electronics.

The discovery of the radioactivity of uranium by Henri Becquerel, a Frenchman, was made that same year. That and the identification of radioactive polonium and radium, in 1898, by Pierre and Marie Curie and of radioactive actinium, in 1899, by André Debierne opened a new frontier in physical science. From that new frontier came the electron as a unit in one of the three sorts of rays from radioactive elements. While actinium was the only one, of those four, that was an electron-emitter,* yet by 1913 all elements were assumed to have electrons in their structure. That assumption provided the basis for explaining X-ray production.

A census of a table of isotopes[1] gave but twenty of the fifty naturally occurring radioactive elements as electron-emitters. Fifteen of those were of atomic number below 83.

"BOILING" ELECTRONS FROM METALS

Roentgen's X-ray tube, by that explanation, was a device for "generating" electrons and blasting them against a metal target by a tremendous electrical push. In Roentgen's experiments the electrons were driven from a cold metal cathode. They were energized by a high electrical potential between that cathode and the tube's anode. The impact on that anode was said to produce gamma-like rays that Roentgen called X-rays.

Some years later, W. D. Cooledge, an American, improved control of the electron beam by heating the cathode metal. He also used a higher electrical potential between the electrodes. He further reduced the gas content of the tube by better evacuation. Thus he made more electrons available for the beam by virtually "boiling" them out of the cathode metal. He also cleared their path of obstructing gas molecules.

The electrode metals are either tungsten or molybdenum. These qualified by virtue of their high melting points. Other metals such as

* NOTE: A dozen or more textbooks of chemistry and physics were inventoried. One half or more, by diagram and description, left the impression that ALL radioactive elements gave off ALL THREE TYPES of rays SIMULTANEOUSLY. One or two, however, did state, "a given element gives off only alpha *or* beta particles, but *not* both." One added, "gamma radiation may accompany alpha or beta emission." Only one, a physics textbook, continued with, "There are a few instances in which the nucleus may emit one particle most of the time yet occasionally the other also. A form of bismuth is an example."

[1] *Handbook of Chemistry and Physics*, 37th edition, 1955, pages 394–447.

the alkalies (lithium, sodium, potassium, rubidium and cesium) release electrons even when at room temperatures. Zinc and iron "evaporate" their electrons when moderately heated. Since all metals are electron-emitters at appropriate temperatures there is a considerable range for choice. However, since an operating X-ray tube is subjected to a high temperature, especially at the anode, the choice fell to the two metals named.

This appeal to heat as an aid to the "generation" of electron rays is used extensively in electronic devices. The A.C. rectifiers, the betatron, amplifier tubes, cathode-ray tubes, electron microscopes and radar are a few of the many. Thermocouples, used for measuring high temperatures and controlling temperature ranges for industrial installations, also belong in this category. In their use, electron transfer, between a pair of joined different metals, is facilitated by the mobilizing effect of the higher temperature. These electrons move, as if by evaporating, from the metal of less electron retention to that of greater. The higher the temperature, the greater the movement. So the current produced is a measure of temperature. Metals much used in thermocouples are: chromium, copper, iridium, iron, nickel, platinum, rhodium and their alloys.

Photo Electronics

Heinrich Hertz is another German who had a part in the development of electronics. In 1887 he found that light also influences the readiness of electron discharge between electrodes under different potentials. Polishing the metal discharge electrode was found to make a difference. Alkali metals were found to be more responsive to light's influence just as they were to temperature effects. Heavier metals, such as iron and zinc, required ultraviolet radiation to produce appreciable electron loss. Practical uses made of this radiation effect include operation of sound-films, auto-counters in traffic control, burglar alarms, switches for the lights upon buoys to guide water nagivation, and camera control for night photography. Here again metals are drafted to serve in the applications of electronics.

Electronics of Solutions

One of the tricks of alchemists was that of causing metals to disappear when put into liquids. After a time it became known that a something other than water had to be added if the trick was to work. And after materials had been classified that "something" was found to either an acid or a salt. Still later, disappearance was described more explicitly in the language of ions. The final word is that here is another application of electronics. Solution, we say, occurs if the ions, already in the liquid, are better electron acceptors than those made

from the metal being dissolved. In the process there is a transfer of electrons from atoms of the dissolving metal to ions already in the solution. A second aspect of the process involves removal of the discharged, former ions, from their solvent.

While the art of dissolving metals has some practical worth a controlled use of it in generating electrons for power-use has greater interest. That control guided the electron transfer in such a way as to put the escaping electrons through some working gadget before they reached the ions to be discharged. Such an arrangement of metal-pairs-in-solutions was called a galvanic cell. It, when developed, became marketable. In this, engineering electronics attracted the world of business.

Assembly of these metal-solution generators ultimately made use of a zinc-copper pair in the Daniell and gravity cells, a zinc-carbon couple in the dry cell, and metal-metallic oxide pairs in the storage batteries. These latter brought lead, nickel and iron into their construction. All of these cells involve the electronics of metals since the source of the energy produced by them stems from the transfer of electrons from some metal or oxide to another metal or ion, maybe through a machine that converts electronic energy into mechanical.

Magneto-Electronics

Energy from batteries was a great convenience. Economically, however, it could not compete with heat power. Basically, battery power leaned heavily on the "push" from the metals that kept the electrons on the go. That "push" was due to the inherent differences in metals for attracting electrons from each other or from neighboring ions. So, in a sense, metals in these cells were the fuels that furnished energy to the electrons on the go. Such fuel was more costly than coal.

Thanks to a Dane, Hans Oersted, and an Englishman, M. Faraday, a new means of providing electron push became available. Oersted, in 1819, found that moving electrons produce a magnetic field about their path. Faraday, in 1831, discovered that moving magnets, in turn, induce electron motion. It was an American, Thomas A. Edison, who geared Faraday's magnetic method, of giving added energy to electron motion, to practical use. His machine, the dynamo, is also called a generator. Strictly speaking it does not generate, it merely accelerates the electron flow. It is well known that this mechanical electron-accelerator did make the convenience of electron energy economically attractive also. In meeting the growing demand for this convenient form of energy metals served an indispensable part. It was through such metals as copper and various alloys of iron that these electrons moved from their accelerators to the places of their use. Also, huge amounts of metals went into the various gadgets that

serve as converters of the electron energy to mechanical use. To call the roll of those that so served would add to copper and iron, already named, others as nickel, tungsten, zinc, chromium, iridium, molybdenum and manganese.

The "Atomic" Battery

Of current interest but, as yet, of very limited industrial promise the "atomic" battery is in the headlines. Here a new metal propellant for electrons enters the picture. The new metal, strontium 90, is strictly a man-made metal, a product of the nuclear reactor. Strontium 90 is radioactive, an electron emitter, with *no* gamma rays and with a half-life of twenty-five years. All those qualities are assets for its job of activating the "atomic" battery.

Strontium 90 is used with germanium and antimony in the construction of a cell that gives a continuous flow of electrons. The electrons move from the antimony through the external circuit back to the germanium. The beta radiation into the germanium, from the strontium 90, loosens the electrons of that semi-conducting metal so that the adjacent antimony becomes electro-negative to the germanium. But, rather paradoxically, it attains discharge back to the germanium through the external part of the circuit. It is reported[2] that this "atomic" battery has been in use two years by the U. S. Navy in guided missiles construction. Even so, with but a limited supply of strontium 90 available, wide use of this electron accelerator is not likely. Its development, however, does prompt the idea that maybe not all the metals for electronics have yet been assessed.

The Electronic Transistor

The photo-electric effect described previously is an aid to the generation of electron rays. But light rays are but a limited portion of the wide band of natural radiations. Other portions of that radiation-spectrum also influence electron emission from matter. The vacuum tube of the radio-receiver uses such radiations. This tube's grid, by its emission of electrons, modifies the current density of a local circuit to reproduce current variations similar to those made by the sending set. But the grid-emitter has to be heated to reach its maximum efficiency. That is an engineering handicap.

Recently another device for radio-reception, and other uses, has been developed.[3,4] It makes use of two new metals. These metals were, previously, without a job. They are germanium and indium. They are rare, as regards percent in the earth's crust. In comparison

[2] Burr W. Leyson, "Marvels of Industrial Science," page 144, E. P. Dutton & Co., New York, 1955.
[3] R. C. Fite, "Germanium, etc.," *Scientific Monthly*, January 1954, pages 15–18.
[4] Burr W. Leyson, *ibid.*, pages 127–139.

with aluminum, germanium is .008 percent as plentiful and indium is but .0001 per cent as great. Fortunately the quantity of these metals required in this transistor is minute on the scale of industry's usual demands. "The germanium bar used to produce a transistor (unit, of the same capacity as a receiver vacuum tube), is only about one ten-thousandth of a cubic inch in volume. The whole (unit) is smaller than a pea. . . . The germanium (wafer) is but a few ten-thousandths of an inch thick."[5] The indium, for its outside coating, is no more than enough to hold the very fine conducting wires for the unit.

The behavior of the germanium's electrons, in this device, is similar to that described in the "atomic" battery above. It differs, however, in that the flow of electrons is discontinuous in the transistor since their emission is conditioned upon the variable radiations from a distant transmitter. Here, the rate of emission is controlled by those radiations while in the "atomic" cell they were activated by electron discharge from the radioactive strontium. In other words, the electron emission here is controlled as they were from the grid, by the incoming radiations.

This transistor has many advantages over the vacuum tube. It requires no special base, is sturdy and resists breakage, is impervious to weather changes, does not need heat to perform at its best, requires no servicing, has a low current consumption, a long life and its small size makes it extremely attractive for small electronic devices.

The foregoing is a sort of sampling report on the indispensable part metals play in the furtherance of electronics. In but few instances do nonmetals so serve. Silicon may substitute for germanium in the "atomic" battery, selenium may be used in some rectifiers and carbon has already been cited as used in the dry cell.

One authority dubbed metals as "the connective tissue of the manufacturing industry." Electronics has added another dimension to metal's service for industry. They might be called "the servants of communications." For full coverage the word "communications" should here include "getting power through" as well as the transmission of "words and symbols." In retrospect, isn't it almost fantastic to think that a minute physical entity, the electron, unknown sixty years ago, is the star performer in all this service rendered by metals?

[5] Burr W. Leyson, *ibid.*, pages 136–138.

Terming school costs "investments in education," the Office of Education estimates that the Nation's public elementary and secondary schools last year expended $380 per pupil for all purposes, or a total of about 10.6 billion dollars.

STATUS OF SCIENCE INSTRUCTION 1946–1956

NORVAL E. ADAMS
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In recent years an increasing interest has been shown in science education and enrollments the country over. Many studies have been made and reported concerning probable trends in secondary and college science courses. In 1946 a plan was developed locally to try to find out the basic changes anticipated by science teachers of the United States concerning trends.

Three hundred and one questionnaires were sent in 1946 to schools of the United States which were representative of each state. The schools were considered typical in that they were schools enrolling 750 or more pupils in the senior high school. The response was most gratifying in that 83% gave usable replies to the study. This cooperation indicated a desire on the part of science teachers to want to know something about trends as a summary of the study was promised and sent to each teacher replying.

The local plan was to make the study in 1946 and then repeat the same study in 1956 to the same schools which replied in 1946. The same questionnaire was sent in 1956. The response was again highly gratifying by the cooperation given. The results of the ten year study have some interesting worthwhile observations to be considered by science educators and administrators. Some of the results of the study are summarized in the areas of organized science program of studies, how to take care of the superior and above average student, desirable characteristics about science departments and science trends.

(*See Questionnaire below and on the following pages 748–750.*)

ELKHART PUBLIC SCHOOLS, ELKHART, INDIANA

SCIENCE QUESTIONNAIRE

SENT IN 1946 AND IN 1956

1. Encircle the plan of your school organization. 6–3–3; 8–4; 6–2–4; 6–6; other.
2. What is your high school enrollment? _____
3. Encircle the grades in your school system that have an organized science program.

   1 2 3 4 5 6 7 8 9 10 11 12
4. Please fill in the information asked in the chart on page 749 for each science in grades 8 to 12, inclusive, in your school curriculum.
5. How many periods (including study halls, etc.) are assigned science teachers per day?
6. What provision is made in your school to take care of the superior and better than average science student? Give answers for each science below.

Science	Better than Average Science Student	Superior Science Student
General Science		
Biology		
Physics		
Chemistry		

7. Do you favor one year of biological science and one year of physical science as the minimum science requirement for high school graduation? _____ If you have exceptions, please comment.

_____

_____

_____

8. Please indicate your answers to the following in spaces provided.

	Gen. Science	Biology	Physics	Chemistry
Do you make any attempt to group students according to ability? If so, what is the basis of grouping into classes?				
Do you attempt to group students according to interests? If so, what specialized classes do you have? i.e. industrial chemistry, household physics, biology for nurses, etc.				
Do you favor a third semester or a second year in the same science? If so, what general characteristic would describe the content of the course? Use margin if more space is needed.				
How many classes do you have which would be most nearly characterized as academic, vocational, or consumer?		Academic_____ Vocational_____ Consumer_____	Academic_____ Vocational_____ Consumer_____	Academic_____ Vocational_____ Consumer_____

9. What extra-curricular activities are sponsored by your school in the field of science; such as clubs, etc.? Answer in space below.

General Science	Biology	Physics	Chemistry

Data	General Science	Physiology	Biology	Physical Science	Physics	Chemistry	Physiography	Others
Grades offered								
Required of all students								
Required of some—elective by some								
Elective by all								
Approximate enrollment in each science								
Number of classes in each science								
Length of period (class)								
Number of periods per week								
Periods spent in laboratory per week								
Number of semesters offered								
(1) Follow text, (2) Multiple texts, (3) Own plan								
Is instruction—(1) Individual, (2) Group								
Are experiments written in detail?								
Is science correlated with other subjects?								
Do students make extensive use of library?								
Are outside projects required?								
How many field trips are taken per year?								
Does "WORKSHOP" describe your laboratories?								

10. What do you consider unique about your science department?

11. What is your opinion of PHYSICAL SCIENCE (some chemistry, physics, and earth science) as an eleventh or twelfth grade science course?

12. Do you think there is a definite trend toward PHYSICAL SCIENCE instead of physics and chemistry for non college-prep students? _____
If you do not now offer Physical Science, do you contemplate introducing the course in the future? _____ If yes, to whom offered? _____

13. What educational trends do you see coming in the field of secondary science?

14. Do you want a copy of the summary? _____
15. Person filling out questionnaire _____ Position

School _____ City _____ State _____

Norval E. Adams, Chairman
Science Department

Organized Science Program of Studies

The question was to indicate the grades in which there is an organized science program in your school system.

1946		1956	
Grades 1–12	14%	Grades 1–12	25%
3–12	2%	3–12	1%
4–12	5%	4–12	2%
5–12	2%	5–12	1%
6–12	3%	6–12	2%
7– 9	1%	7– 9	1%
7–12	29%	7–12	26%
8– 9	1%	8– 9	2%
8–12	11%	8–12	10%
9–12	28%	9–12	21%
10–12	3%	10–12	6%
11–12	1%	11–12	3%

Some schools offer a broader field of science in that a variety of sciences are taught. The sciences which are taught beyond the traditional biology, physics and chemistry in some schools are listed below for comparison by years.

1946	1956
Radio	Physiography
English Science	Physiology
Physical Science	Aeronautics
Photography	Botany
Radio Code	Zoology
Astronomy	Psychology
Aeronautics	Electronics
Zoology	Radio
Botany	Radar
Forestry	Time and Space
Agriculture	Electricity
Physiology	Advanced Biology
Senior Science	Laboratory Techniques
Shop Science	Bacteriology
Electricity	Conservation
Meteorology	Seminar
Electronics	Household Science
Descriptive Physics	Science Survey
Descriptive Chemistry	Earth Science
Physiography	Related Chemistry
General Science	Related Physics

Superior and Above Average Students

A major problem seems to be how to take care of the superior and better than average science pupil. Science teachers have various methods of taking care of individual differences. The following methods were used.

1946	1956
Individual projects are encouraged.	Encouraged to enter science fairs.
Individual supplementary laboratory work is required.	Our students participate in national contests.
Problems are taken from College manuals.	Outside reports are required.
College texts are made available.	Special projects are required for A & B students.
We make laboratory assistants of them.	We have active science clubs. There was about 15% increase in clubs during the ten year period. 59% report active biology club, 72% active physics club, 79% active chemistry club with 43% reporting a single club for all sciences.
Superior students set up demonstrations.	We work with the Junior Academy of Science.
They are urged to use the laboratory after school.	Make laboratory assistants of them.
Special help is given to qualify for Science Talent Search.	We have honors classes in each science.
We offer technical science for the talented and descriptive science for the others.	We require extra experimentation.
Workshop days are designated in which students demonstrate something they have been working on.	Science is taught at different levels.
Pupils are encouraged to establish laboratories at home.	We make the laboratory available at all times.
They are permitted to take advanced work.	One teacher is in charge of science projects.
	Encouraged to use more than one textbook.

Teachers have frequent conferences with the superior pupils.

A senior seminar is offered in each science.

They construct equipment for the laboratory.

Desirable Characteristics about Science Departments

Each science department seemingly has some unique characteristic worthy of consideration by others. The question asked was—What do you consider outstanding about the science department in your high school?

1946

We have fine facilities and equipment.

Continuous science from grade 1–12 are offered.

Graduates make good success in college.

Pupils are classified as to ability (I.Q., reading, interests).

Laboratory work is all individual.

Science is taken voluntarily.

Most of our equipment is built by students.

Our visual aids are excellent.

Good students work on projects.

We adhere to rigid requirements for our best students.

Our science staff work in complete harmony.

Consumer science is beginning to be emphasized.

Better pupils get more consideration than poorer ones.

We have our own manuals.

The problem type of approach is made in science.

Standardized tests are used for examinations.

Extra credit plan in which a pupil may work in any field of science which has his special interest along with his regular science.

Our science rooms are supplied with several sets of different texts.

We have small classes which permits individual attention.

Classrooms and laboratories are combined as a unit.

Students are encouraged to do projects involving college texts and manuals.

All teachers are above average.

Scientific principles are stressed from the teaching angle.

1956

Honor classes are formed for above average pupils.

Two levels of chemistry and physics are taught—both meeting college entrance.

We offer a large variety of sciences.

A high interest in science exists in our high school.

We have classes for slow readers in science.

Nearly all of our students take physics or chemistry.

We have an unusual amount of experimentation.

Our standards of work are very high.

A large number of our graduates major in high school science.

All of our students are required to take two years of science to graduate. 76% of replies indicated this as highly desirable.

Our faculty work together in planning courses and techniques.

The vertical integration in science from grades 1–12 is excellent.

Each teacher has his own laboratory-classroom combination.

Science teachers have no extra duties except club and project.

We have extensive field work in science.

No science is required for graduation.

An attempt is made to identify the superior student as early as possible.

Laboratories are made available after school and on Saturday.

We have close cooperation between scientists and engineers in the area.

Unlimited freedom is given in our science teaching.

Each teacher is free to teach his science as he pleases and no two teachers follow the same plan, schedule or emphasize the same topics.

Sex education is required in the seventh grade.
A twenty-four hour weekly class schedule is standard.
Each student must complete an outside major project in each science.
We have a good museum.
Fifty percent of our students are enrolled in science.
We have not watered down our requirements in science which seems to be a general trend in this country.
Outstanding students are used as laboratory assistants or as student teachers in Junior high school.
We have no Liberal Arts teachers teaching science.
Library facilities are excellent and are extensively used.
Our chemistry laboratory uses semimicro technique.

Predictions of Science Trends

What trends do you see coming in the area of secondary science? The following anticipated trends are arranged in the order of frequency as given by science teachers and administrators. You will note some trends very similar but the school reporting had a different viewpoint due to science offerings.

1946

Emphasis will be placed upon consumer science and leisure time activities.
Schools must better serve the great number who do not go to college.
There will be more visualized science taught.
Specialized courses will be offered to the few gifted pupils.
Segregation into college prep and noncollege prep students will be needed.
There will be a trend to bring the sciences into more complete harmony with the experience of the pupil and with less theory.
A greater emphasis will be placed upon a few topics rather than a survey of the whole field.
A greater attention will be given to the higher I.Q.
A greater emphasis on science will be given in our high school curriculum.
A revision of chemistry and physics into academic, vocational and general fields will be needed.
A 12 year science program of studies will be offered.
Less work will be made on problem solving and equation balancing and more on useful general information.
Eventual removal of the "College yoke" from the neck of high school science.

1956

Emphasis will be placed upon rigorous science courses.
More science and mathematics with higher standards of work will be required.
More rigid selection of students and more efforts to induce able students to prepare for scientific careers will be made.
More generalized courses will be offered.
More electronics courses will be taught.
There will be a swing back to pure science.
Teachers of science will hold Ph.D.
A move toward problem and project method of teaching science will be evident.
More vocational and consumer science will be offered.
All pre-college people will be required to take physics and chemistry.
Require more science for the people who will not be scientists.
More specialized courses such as biological chemistry will be offered.
There will be greater opportunities for science teachers.
A trend for more required subjects and fewer electives.
Trend toward biology and physical science in the smaller schools is coming.
There is a trend away from science.

Our best secondary schools will require both biological and physical sciences in order to graduate. 71% of the 1946 replies favor this requirement.

Laboratories will become workshops of science.

More pamphlets will be written which are interesting to students and not merely to show the vocabulary range of the writer.

Science will be crowded out of the curriculum by easy courses.

There will likely be a weakening of the courses due to the public demand for "Johnnie" to pass.

An effort will be made to get more students enrolled in physics and chemistry. Science fairs will be a contributing factor.

Secondary science will disappear from the small school.

A lot will be written about science education and a lot said, but little evidence will be shown by the results.

Principles and concepts will be taught with far less emphasis upon descriptive work, workbooks, busy work and memory work.

Techniques of Science Instruction

A comparison of the techniques of science instruction as reported by science teachers is shown for 1946 and 1956 in the chart which follows. The percentages placed in italics are for 1956 and are from the same schools reporting in 1946 which are placed in black in the chart. A study of the chart seems to indicate a lot of stability in the thinking and planning of science teachers.

Other Observations from This Study

It seems that science teachers are beginning to be recognized as personnel which should be given additional time in the school day for laboratory preparation. In 1946 only 43% were assigned five periods including study halls and other assignments. In 1956 study from the same schools shows that the percentage has jumped to 54%. The length of the period most frequently reported was 55 minutes.

The extra-curricular activities in science have increased in the ten year period. Active general science clubs have jumped from 29% to 34%, biology from 58% to 59%, physics from 61% to 72%, and chemistry clubs from 64% to 79%. Could this club program increase in physics and chemistry be due to the desire of alert science teachers to cope with the decreasing enrollment in physics and chemistry?

There seems to be considerable interest among some science organizations to require one year of biological science and one year of physical science as the minimum science requirement for high school graduation. 71% of the teachers replying in 1946 indicated that they favor the two years of science as a minimum requirement. The 1956 replies indicated that 76% were favorable.

In 1946, 38% of the schools replying indicated that there was a definite trend towards physical science instead of physics and chem-

TECHNIQUES OF SCIENCE INSTRUCTION AS REPORTED BY SCIENCE TEACHERS

Subject	Type of Instruction	Experiments Written in Detail	Correlation with Other Subjects	Use of Library	Outside Projects Required	Field Trips	Workshop Plan	Textbook Plan
Biology	Individual 11% *Individual 15%* Group 89% *Group 85%*	Yes 53% *Yes 57%* No 47% *No 43%*	Yes 60% *Yes 67%* No 40% *No 33%*	Yes 63% *Yes 66%* No 37% *No 34%*	Yes 53% *Yes 54%* No 47% *No 46%*	Some 63% *Some 70%* None 37% *None 30%*	Yes 52% *Yes 51%* No 48% *No 49%*	One Text 46% *50%* Multiple 40% *38%* Own Plan 14% *12%*
Physics	Individual 14% *Individual 19%* Group 86% *Group 81%*	Yes 77% *Yes 78%* No 23% *No 22%*	Yes 63% *Yes 66%* No 37% *No 34%*	Yes 45% *Yes 52%* No 55% *No 48%*	Yes 41% *Yes 33%* No 59% *No 67%*	Some 54% *Some 57%* None 46% *None 43%*	Yes 64% *Yes 53%* No 36% *No 47%*	One Text 54% *44%* Multiple 27% *40%* Own Plan 19% *16%*
Chemistry	Individual 13% *Individual 18%* Group 87% *Group 82%*	Yes 73% *Yes 72%* No 27% *No 28%*	Yes 63% *Yes 64%* No 37% *No 36%*	Yes 51% *Yes 54%* No 49% *No 46%*	Yes 41% *Yes 30%* No 59% *No 70%*	Some 51% *Some 58%* None 49% *None 42%*	Yes 63% *Yes 56%* No 37% *No 44%*	One Text 48% *50%* Multiple 32% *26%* Own Plan 20% *24%*
Physical Science	Individual 20% *Individual 17%* Group 80% *Group 83%*	Yes 12% *Yes 57%* No 88% *No 43%*	Yes 76% *Yes 52%* No 24% *No 48%*	Yes 66% *Yes 52%* No 34% *No 48%*	Yes 54% *Yes 33%* No 46% *No 67%*	Some 36% *Some 62%* None 64% *None 38%*	Yes 43% *Yes 49%* No 57% *No 51%*	One Text 44% *59%* Multiple 32% *21%* Own Plan 24% *20%*
Physiology	Individual 12% *Individual 6%* Group 88% *Group 94%*	Yes 48% *Yes 52%* No 52% *No 48%*	Yes 68% *Yes 86%* No 32% *No 14%*	Yes 73% *Yes 76%* No 27% *No 24%*	Yes 41% *Yes 25%* No 59% *No 75%*	Some 55% *Some 56%* None 45% *None 44%*	Yes 80% *Yes 50%* No 20% *No 50%*	One Text 42% *50%* Multiple 20% *26%* Own Plan 38% *24%*

The percents in black in this chart indicate the results of the 1946 study. *The percents in italics in this chart indicate the results of the 1956 study and are the answers from the same schools as the 1946 study.*

istry for the non-college prep students. In 1956, 59% of the same schools that replied in 1946 indicated there was a definite trend toward physical science. The most favorable comments concerning physical science came from the schools that were offering the course. The most common adverse criticism was that it was merely a course in which units of work were lifted from physics and chemistry and was taught in a too academic fashion.

Summary

In general it appears that science teachers are thinking how to better adapt their science courses to the pupil's needs. There seems to be a desire on the part of science teachers to make their courses more rigorous and challenging to the better than average pupil.

Many schools report that no science clubs are available to the pupils because the teachers do not have the time to organize and conduct such clubs.

There seems to be a general feeling among science teachers that the gifted student is not receiving proper consideration. It seems that many science courses are geared for the average student.

Many teachers said, "A lot will be written about science education and a lot said, but little evidence will be shown by the results." Isn't this prediction a challenge to science organizations and science departments of secondary and college levels?

GOVERNMENT RELEASES REPORT ON FEDERAL AID TO STUDENTS

Two years ago every sixth undergraduate student in college in the United States received money for his education from the Government.

Together with graduate and postdoctoral students, a total of 390,000 young Americans received on the average $1,000 each for instruction in all fields of study.

These figures, broken down to show Federal support for science students in higher education in this country, were released here today by the National Science Foundation. They were made public to help planners evaluate proposals for Government-financed scholarship programs now being considered. Such programs might be one answer to solving the current scientific manpower shortage.

The report shows that the more advanced a student is in his scientific training, the greater his chances for receiving Government aid.

While only 82,000, or one-fourth, of the undergraduates receiving aid were pursuing scientific studies, approximately one-half or 18,000 graduate students and virtually all, 1,300, postdoctoral students receiving aid were preparing for careers in science.

By far the greatest aid was given through the veterans' educational benefits. Practically all of the undergraduate students in all fields receiving Government money were veterans of the Korean conflict, studying under Public Law 550.

The report also shows that more than one out of every three students receiving Federal aid for graduate work was employed as a research assistant.

PROBLEM DEPARTMENT

CONDUCTED BY MARGARET F. WILLERDING
San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the Department desires to serve his readers by making it interesting and helpful to them. Address suggestions and problems to Margaret F. Willerding, San Diego State College, San Diego, Calif.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2521. *Proposed by Richard H. Bates, Milford, New York.*

In a parallelogram of sides a and b and included angle θ, a diagonal is drawn. In each triangle thus formed a circle is inscribed. Derive a formula for the line of centers of these circles in terms of a, b, and θ.

Solution by the proposer

In the figure:

$$AP=AS=\frac{r}{\tan\frac{1}{2}\theta}; \qquad PB=BQ=a-\frac{r}{\tan\frac{1}{2}\theta}; \qquad DS=DQ=b-\frac{r}{\tan\frac{1}{2}\theta}$$

$$BD=BQ+QD=a+b-\frac{2r}{\tan\frac{1}{2}\theta}$$

$$QM=BM-BQ=\frac{b-a}{2}$$

$$OM=\tfrac{1}{2}OO' \quad \text{and} \quad \overline{OM}^2=r^2+\frac{b-a^2}{2}$$

From a well-known relationship:

$$\tan\tfrac{1}{2}\theta=\frac{r}{s-c}$$

$$r^2=(s-c)^2\tan^2\tfrac{1}{2}\theta$$

But:

$$(s-c)=\frac{a+b+\sqrt{a^2+b^2-2ab\cos\theta}}{2}-\sqrt{a^2+b^2-2ab\cos\theta}$$

And:

$$\tan^2 \tfrac{1}{2}\theta = \frac{1-\cos\theta}{1+\cos\theta}$$

Making these substitutions:

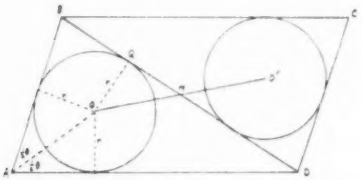
$$r^2 = \left[\frac{a+b-\sqrt{a^2+b^2-2ab\cos\theta}}{2}\right]^2 \cdot \left[\frac{1-\cos\theta}{1+\cos\theta}\right]$$

And:

$$OM^2 = \left[\frac{a+b-\sqrt{a^2+b^2-2ab\cos\theta}}{2}\right]^2 \left[\frac{1-\cos\theta}{1+\cos\theta}\right] + \left[\frac{b-a}{2}\right]^2$$

So:

$$OO' = 2OM = \sqrt{\frac{(3-\cos\theta)(a^2+b^2-2ab\cos\theta)+2(a+b)(\cos\theta-1)\sqrt{a^2+b^2-2ab\cos\theta}}{(1+\cos\theta)}}$$



NOTE: this is a generalization of Problem 2446 whose solution appeared in this department in the May 1955 issue.

Solutions were also offered by C. N. Mills, Sioux Falls, S. D.; and Mrs. Walter R. Warne, St. Petersburg, Fla.

2522. *Proposed by A. B. Lonski, Los Angeles, Calif.*

A horse is tethered on the circumference of a circular field, the area of which is one acre. Determine the length of rope so that the horse may graze on half of the circular field.

Solution by Alan Wayne, Baldwin, N. Y.

Let b be the length of rope, and let a be the radius of the field. Then $b = 1.15872\,a$ (see Solution to Problem 1886, SCHOOL SCIENCE AND MATHEMATICS, Vol. 44, No. 9, December 1944, page 869). But $\pi a^2 = 1$ acre $= 43{,}560$ sq. ft. Thus $a = 117.75$ ft, and $b = 136.4$ feet.

Solutions were also offered by C. N. Mills, Sioux Falls, S. D.; and the proposer.

EDITOR'S NOTE: This problem appears in *One Hundred Mathematical Curiosities*, by William R. Ransom, J. Weston Walch, Publisher, Portland, Maine, on page 166.

2523. *Proposed by F. A. Lee, Jr. Lynchburg, Va.*

A room is in the shape of a rectangular parallepiped, "a" units long, with ends squares of length "b." A point A is on one end, one unit down from the ceiling and half-way across; a corresponding point B is on the other end one unit up from the floor and half-way across.

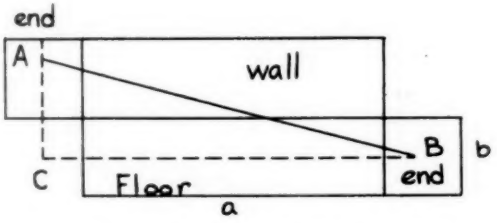
One pathway from A to B is straight down the wall from A to the floor, straight across and up to B. This distance is $a+b$.

To find integral (or rational) values of a and b for which there are other path-

ways from A to B equal to $a+b$, these pathways to be measured along any or all of the following: ceiling, sides, ends, floor.

Solution by Proposer

Case 1



The required pathway is AB. Complete right triangle ABC.
To find values of a and b so that

$$AB=a+b$$

$$\overline{AB}^2=\overline{BC}^2+\overline{AC}^2=(a+b)^2$$

$$BC=a+\frac{b}{2}+1 \qquad AC=b-1+\frac{b}{2}=\frac{3b}{2}-1$$

Then

$$\left(a+\frac{b}{2}+1\right)^2+\left(\frac{3b}{2}-1\right)^2=(a+b)^2$$

Simplifying,

$$3b^2-2(a+2)b+4(a+1)=0$$

$$\therefore\ b=\frac{(a+2)\pm\sqrt{(a+2)^2-12(a+1)}}{3}$$

Let

$$a=11$$

$$b=\frac{13\pm5}{3}=6,\quad \frac{8}{3}$$

$$a=1 \qquad a=11$$

$$b=6 \qquad b=\frac{8}{3}$$

Case 2

To find values of a and b for which

$$AB=a+b$$

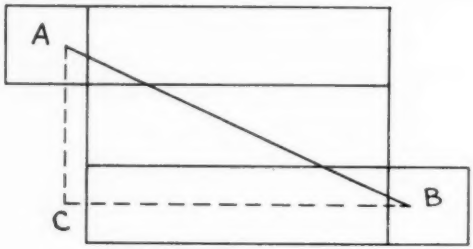
$$\overline{AB}^2=\overline{BC}^2+\overline{AC}^2=(a+b)^2$$

$$BC=a+2 \qquad AC=2b$$

$$(a+2)^2+(2b)^2=(a+b)^2$$

$$3b^2-2ab+4(a+1)=0$$

$$b=\frac{a\pm\sqrt{a^2-12(aH)}}{3}$$



Let

$$a=19$$

$$b=\frac{19\pm 11}{3}=10,\quad \frac{8}{3}$$

$$a=19 \qquad a=19$$

$$b=10 \qquad b=\frac{8}{3}$$

2524. *No solution has been offered.*

2525. *Proposed by J. W. Lindsay, Amarillo, Texas.*

Solve

$$\sqrt[3]{e^{2-x}}\sqrt[4]{e^{4-x}}\sqrt[5]{e^{5x-1}}=1$$

Solution by Charles H. Butler, Kalamazoo, Michigan

Taking natural logarithms of both members of this equation we get

$$\frac{2-x}{3}+\frac{4-x}{4}+\frac{5x-1}{5}=0$$

Solution of this equation gives

$$x=-\frac{88}{25}$$

Solutions were also submitted by Laura Elam, Rochester, N. Y.; M. Freed, Los Angeles, Calif.; Benjamin Greenberg, New York, N. Y.; Brother Felix John, Philadelphia, Pa.; F. A. Lee, Jr., Lynchburg, Va.; Mary Townley, Bristow's Station, Va.; Walter R. Warne, St. Petersburg, Fla.

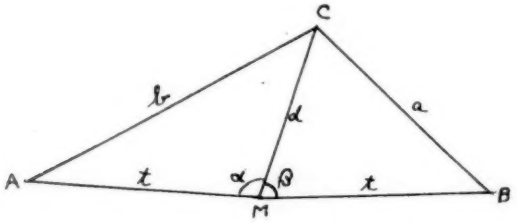
2526. *Proposed by Charles H. Butler, Kalamazoo, Michigan.*

Prove the existence of a triangle ABC in which $m_c<a<b$, with m_c, a, b in arithmetic progression, and give formulas for a and b in terms of m_c and the third side $c(=AB)$ of the triangle.

Solution by the proposer

Let us assume triangles AMC and BMC joined as shown in the accompanying diagram, with $d<a<b$, and $AM=BM=t$. Let us assume further that d, a, b are in arithmetic progression: that is, that $a-d=b-a$. Our figure $AMBC$ then would satisfy all the requirements for the existence of the triangle in question if we could establish further conditions such that A, M, and B would also lie on the

same straight line. Now if and only if angles α and β were supplementary, then AMB would be a straight line and our two triangles would form a single triangle ABC in which d would be the median from the vertex C to the side AB, and in which, at the same time, d, a, and b would be in arithmetic progression, thus satisfying the required conditions.



Our first problem, then, is to determine whether (with d, a, b in arithmetic progression) AMB can be a straight line, and if so, under what conditions. This, in turn, reduces itself to finding the conditions, if any, under which angles α and β can be supplementary, and that could happen only if $\cos\alpha=-\cos\beta$, or $\cos\alpha+\cos\beta=0$, since neither angle can exceed 180°.

Now since d, a, b are to be in arithmetic progression, let $a=d+x$ and $b=d+2x$. Then applying the law of cosines to triangles AMC and BMC successively, we get

$$\cos\alpha=\frac{t^2-4dx-4x^2}{2dt}$$

$$\cos\beta=\frac{t^2-2dx-x^2}{2dt}.$$

Setting $\cos\alpha+\cos\beta=0$ and solving for x in terms of d and t, we get $5x^2+6dx-2t^2=0$ whence

$$x=\frac{-3d+\sqrt{9d^2+10t^2}}{5}.*$$

We therefore find that α and β will be supplementary and ABC will be a triangle in which d, a, b will be in arithmetic progression provided that their common difference $x=a-d$ or $b-a$ is given by the relation

$$x=\frac{-3d+\sqrt{9d^2+10t^2}}{5}.$$

Upon substituting m_c for d and $\frac{1}{2}c$ for t and simplifying, this gives

$$x=\frac{-6m_c+\sqrt{36m_c^2+10c^2}}{10}.$$

This yields formulas for a and b as follows:

$$a=m_c+x=\frac{4m_c+\sqrt{36m_c^2+10c^2}}{10}$$

$$b=m_c+2x=\frac{-m_c+\sqrt{36m_c^2+10c^2}}{5}$$

Solutions were also offered by Benjamin Greenberg, New York, N. Y.; and Anna Porter, Ovid, N. Y.

* Note that since d and x must both be positive, only the positive sign can be used before the radical.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2523, 2525, 2526. *Nathaniel Queen, 228 East 91st St., Brooklyn, N. Y.*

2525. *Richard E. Snider and Lewis F. Meyer, Firelands High School, Oberlin, Ohio.*

2525. *Charles W. King, Denton, Md.*

2525. *Thomas H. Cahall, Susie Cooper, Michael H. Everngam, Richard A. Maytin, Hank Nuttle, John F. Osinski, Jr., Conrad Scurto, Eddie Segar, and Jimmy Ward all of Caroline High School, Denton, Md.*

2525. *Franklin Cheek and Ronald L. Heilmann, Rufus King High School, Milwaukee, Wis.*

PROBLEMS FOR SOLUTION

2545. *Proposed by Hugo Brandt, Chicago, Ill.*

Find the shortest chord normal, at one end, to the parabola $y^2 = 2mx$

2546. *Proposed by Howard D. Grossman, New York, N.Y.*

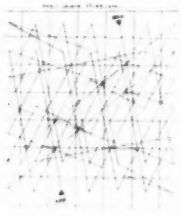
Prove (a) the sum of the areas of any three faces of a tetrahedron is greater than the area of the fourth face; (b) the plane area bounded by a broken line (or curve) in a plane is the smallest area bounded by that curve.

2547. *Proposed by Julian Sumner Miller, El Camino, Calif.*

A mass m suspended from a fixed point by a string of length r hangs vertically. The mass is given an impulsive blow and is thus projected horizontally with a velocity v. Find where the string becomes slack.

2548. *Proposed by Harry Frye, Tullahoma, Texas.*

Below is a maze magic square of lines. With pencil trace the maze and put in the correct numbers so as to produce a magic square of the seventh order.



2549. *Proposed by Brother Felix John, Philadelphia, Pa.*

Find the conditions, among its coefficients, that the expression

$$ax^6+6bx^5y+15cx^4y^2+20dx^3y^3+15ex^2y^4+6fxy^5+gy^6$$

should be reducible to the sum of the sixth powers of two linear expressions in x and y.

2550. *Proposed by Sandra Bihrer, Sac City, Iowa.*

In triangle ABC, R, the circumradius, equals $2r$, r, the in-radius. Prove that ABC is equilateral.

EDITOR'S NOTE. There is a need for problems for this department. Please submit original problems to the editor.

BOOKS AND PAMPHLETS RECEIVED

IRRATIONAL NUMBERS, by Ivan Niven, *Professor of Mathematics. University of Oregon.* Cloth. Pages xii+164. 12.5×18.5 cm. 1956. John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y. Price $3.00.

COAL-MINING, by I. C. F. Statham, M. Eng., M. I. Mon. E., F.G.S., *Professor of Mining, University of Sheffield.* Cloth. Pages xi+564. 22×14 cm. 1956. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $15.00.

LEARNING WITH SCIENCE, by Gerald S. Craig, *Professor of Natural Sciences, Teachers College, Columbia University;* Charles K. Arey, *Associate Professor of Education, University of Alabama;* and Mary E. Sheckles, *Instructor of Natural Sciences, Teachers College, Columbia University.* Cloth. 340 pages. 18×23.5 cm. 1956. Ginn and Company, Statler Building, Boston 17, Mass. Price $2.96.

JOLLY NUMBERS. Beginners' Course. Combined Primer and Book One, Revised Edition, by Guy T. Buswell, *University of California, Berkeley;* William A. Brownell, *University of California, Berkeley;* Lenore John, *Laboratory Schools, The University of Chicago;* and Louis Delle Pittman, *Public Schools, Durham, North Carolina.* Paper. 74 pages. 22×29.5 cm. Ginn and Company, Stattler Building, Boston 17, Mass. Price 84 cents.

ENCOURAGING SCIENTIFIC TALENT, by Charles C. Cole, Jr. Paper. Pages ix+259. 16.5×24.5 cm. College Entrance Examination Board, 425 West 117th Street, New York 27, N. Y. Price $3.50.

TEACHER'S GUIDE AND ANSWERS FOR THE SCRIBNER ARITHMETIC, Book 8, by William A. Gager, Dorris H. Johnson, Carl N. Shuster, Richard Madden, and Franklin W. Kokomoor. Paper. 172 pages. 22.5×30 cm. 1956. Charles Scribner's Sons, 597 Fifth Avenue, New York 17, N. Y. Price $1.80.

PEOPLE AND TIMBER, A CONDENSED SUMMARY OF THE TIMBER RESOURCE REVIEW. Paper. 15 pages. 19.5×25 cm. June 1956. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price 20 cents.

THE SECONDARY SCHOOL PLANT: AN APPROACH FOR PLANNING FUNCTIONAL FACILITIES, by James L. Taylor, *Specialist on Planning School Buildings, under the Direction of Ray L. Hamon, Chief.* Special Publication No. 5. Pages viii+60. 19.5×26 cm. 1956. Superindendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 45 cents.

OFFERINGS AND ENROLLMENTS IN SCIENCE AND MATHEMATICS IN PUBLIC HIGH SCHOOLS, by Kenneth E. Brown, *Specialist for Mathematics.* Paper. Pages vi+24. 15×23 cm. Pamphlet No. 118. Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Price 15 cents.

Electronic Alarm to ward off burglars employs an infrared modulated light. Two cones are used, one giving off "black" light at a specified number of cycles per second and the second receiving the signal. Any body passing through the invisible beam trips off the alarm. The system operates on 110-volt, 60-cycle electrical supply.

BOOK REVIEWS

PHILOSOPHICAL WRITINGS OF PEIRCE. Selected and Edited by Justus Buchler, *Associate Professor of Philosophy at Columbia University*. Paper. Pages xvi+386. 20.5×13.6 cm. 1955. Dover Publications Inc., 1780 Broadway, New York 19, N. Y. Price $1.95.

Charles S. Peirce, it is said, was "recognized as an equal by such men as William James and John Dewey." These "writings" are selected and "interwoven" by the editor in order to give a "balanced exposition of Peirce's complete thought."

There are twenty eight-chapters, an introduction by the editor with notes and a generous index. Footnote citations help the reader to make a critical check upon the editor's selections in the event he wishes so to do.

Aspects of the author's philosophical thinking may be inferred from some of the phrasings from chapter titles. One finds in the Table of Contents: "Scientific attitude and fallibilism; Validity of reasoning; Abduction and induction; Doctrine of chance; Nature of mathematics; Probability of induction; Essentials of pragmatism; Architecture of theories; Evolutionary love and The concept of God." The first chapter is an autobiograph which, as a backdrop, aids in assessing the subjective elements that might be in the chapters that follow.

Dr. Buchler, an experienced author in his own right, edits and provides a preface and the introduction.

Readers who lean upon human interest appeal will find sections of this book heavy going. Philosopher Peirce puts it, "My book will have no instruction to impart to anybody. . . . (It) is meant for people who *want to find out*." And it may be added that he who no more than scans a section will thereby increase his chances of finding the reality of what he "*finds out*."

B. CLIFFORD HENDRICKS
Longview, Washington

DIFFERENTIAL EQUATIONS by Harry W. Reddick, *Visiting Professor of Mathematics, Syracuse University*, and Donald E. Kibbey, *Professor of Mathematics, Syracuse University*. Third Edition. Cloth. Pages ix+304. 13.5×21.5 cm. 1956. John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N. Y. Price $4.50.

This third edition, like earlier editions, might be classified as a standard text for a first course in differential equations. The second edition was reviewed in SCHOOL SCIENCE AND MATHEMATICS for April, 1950 (page 336). Changes are not more than would be expected in a revision: The first three chapters were combined into two, with some rewriting, but no radical changes; the third edition includes a page and a half of discussion of the adjoint equation in the chapter on second order linear equations.

In many cases changes in problems consist in merely altering a numerical constant or a sign, a very appreciable number of the problems have not been altered. Teachers who desire a change because of the growing file of solved problems in fraternity houses will not feel that there has been sufficient alteration (the student using this method will perhaps not notice that problem 24 on page 231 of the third edition is not identical with problem 24 on page 241 of the second edition—it would be unusual if both problems are correctly stated).

Instructors pleased with earlier editions will no doubt continue to like this one; if the earlier editions were not satisfactory, the changes are not sufficient to make this one palatable. The text certainly merits consideration when a new text is to be adopted.

CECIL B. READ
University of Wichita

INTERMEDIATE ANALYSIS, AN INTRODUCTION TO THE THEORY OF FUNCTIONS OF ONE REAL VARIABLE by John M. H. Olmstead, *Professor of Mathematics*,

University of Minnesota. Cloth. Pages xii+305. 16.5×24 cm. 1956. Appleton-Century-Crofts, Inc., New York, N. Y. Price $6.00.

The author feels that the typical student finishing a year of calculus may have manipulative skills but lacks knowledge of the nature of a precise analytical proof. To assist him in gaining this knowledge earlier than is customary, this text presents basic ideas and techniques of analysis as illustrated in the study of functions of a real variable. The author points out, and this reviewer would agree, that much of the text can be handled by students with a background of a year course in calculus; other portions, usually starred, will require more mathematical maturity. In the opinion of the reviewer it is possible that in some places this objective of great flexibility (and hence perhaps a larger potential market) has detracted somewhat from the value of the text.

It would indeed be an illuminating experience to use this book in the first course after the calculus. Although there is some flexibility, in some places the order of the topics as presented in the text must be followed. As illustrative of the wide range of topics covered, some representative subjects are listed. By no means is this exhaustive, moreover, the apparent range does not consider the degree of rigor with which the topic is presented. The delta-epsilon definition for convergence; the fundamental theorem of integral calculus; uniform continuity; mathematical induction [one wonders why no examples of formulas which are *not* true are included]; limit theorems for sequences; reduction formulas for integration; point set theory; L'Hospital's rule; curve tracing; hyperbolic functions; the Riemann-Stieltjes integral; infinite series; uniform convergence; the Weierstrass uniform approximation theorem;—these are samples, perhaps not random. There is a large number of exercises, more than usually found in a text on real variables, with answers to many of them.

The book is somewhat unique in its approach; a review can not do much more than create interest. Anyone even remotely considering a course of the type suggested should certainly examine this text.

CECIL B. READ

MATHEMATICAL ANALYSIS, A MODERN APPROACH by Walter T. Hamilton, *Assistant Professor of Mathematics, Long Island University* and John Raymond Hamilton, *Assistant Professor of Mathematics, Long Island University.* Cloth. Pages xiii+379. 16×24 cm. 1956. Harper and Brothers, 49 East 33rd St., New York 16, N. Y. Price $4.50.

Whether inclusion of the word "modern" in a title really makes the treatment modern is debatable. Certainly the approach is in some respects different; it does not go so far as certain books recently published and include such topics as Boolean algebra, groups, and fields. One of the most surprising features is to find trigonometry introduced after the treatment of analytic geometry and some elementary differential and integral calculus. [The slope of a line is defined as the ratio of the *rise* of the line to its *run*.] In general it seemed that each of the traditional subjects remains essentially compartmentalized, although the traditional order is altered.

The first two chapters, approximately 25 pages each, treat mathematical logic (including logic of classes) and the real number system. The next 125 pages treat what is essentially intermediate and college algebra. This is followed by about 40 pages of elementary analytic geometry—straight line, circle, parabola, parallel and perpendicular lines, elementary curve tracing. Approximately 50 pages is devoted to introductory topics in the differential and integral calculus, then 60 pages of trigonometry. About 20 pages are devoted to polar coordinates and complex numbers.

The reviewer found the print was a little tiring to read. He was pleased to find that in general the authors were careful to include needed restrictions on definitions (for example, the condition that the base must not be zero in certain laws of exponents). Certain other features may not meet with general agreement. There

may be a teaching advantage in the use of "false" rather than "extraneous" roots, but this may cause the student difficulty later. From the first portion of page 146, since it is emphasized that the mantissa is a *positive* decimal fraction, the common logarithm of 10 has no mantissa; the last paragraph on the same page states that numbers listed in common logarithm tables are all mantissas, the table on page 351 certainly lists the mantissa [or is it?] 0000. Some will disagree with the definition "An angle is a measure of rotation"; or the statement, "The division of mathematics devoted to the study of functions is called calculus"; or that "equations of a degree higher than the second usually cannot be solved conveniently by purely algebraic methods."

CECIL B. READ

MORE EMPHASIS NEEDED ON SCIENCE

More emphasis must be placed upon the sciences throughout the American educational system if we are to maintain our standard of living and meet the threat of rapidly advancing Russian technology, S. E. Skinner, Vice President of General Motors in Charge of the Accessory Group, said.

"More than ever before the inquiring mind must be brought into play," Mr. Skinner said. "Our fundamental challenge . . . is to provide the manpower with the requisite mental equipment and training."

Our population increase alone represents a challenge to education that must be met if we are to continue a growing economy, he said. New products, new industries and new and better ways of doing things must be discovered tomorrow by the youth of today.

"Right now the United States needs more engineers and scientists, and this need will increase rather than diminish in the years to come," Mr. Skinner said. "The pace of progress has been accelerating. The time lag between fundamental discovery and its development into things useful for our daily living has been shrinking."

Where does the United States stand with respect to trained manpower as the need increases for specialized technology and fundamental scientific inquiry, Mr. Skinner asked.

"The picture is not a pleasant one to contemplate," he said. "It has been estimated that we need a yearly influx of 45,000 to 50,000 engineers and scientists. Currently our schools are graduating half as many, whereas in the Soviet Union more than that number go from the technical schools into state employment each year."

So far we have the edge on Russia in total numbers of scientific and technical personnel, Mr. Skinner said, but it has been estimated that in less than five years the Soviets will overtake us if we don't get more young people into the sciences and technology.

The proportion of our students in high school who study physics, algebra, geometry and chemistry has dropped alarmingly since 1900, he said, while in Russia all secondary students take these subjects and those who show promise are pushed along.

"It seems clear that at the secondary level education in this country has been allowed to drift along the line of least resistance. 'Snap-course' electives are popular. The emphasis in some high schools has been more and more on studies that in some not very well defined manner are supposed to prepare the student for 'life.' And in the process, as we have been told recently, many of these boys and girls do not even learn how to read very well," he said.

"I hasten to state that I have no desire to indict the teaching profession or our secondary school administrators," Mr. Skinner stated. "The problem goes deeper than that. It is one which must concern all of us—as citizens, teachers and businessmen; but above all as parents. For I sincerely believe that the cure must begin at home."

CHRISTMAS FILMS

Enthusiasm of children for the Christmas holiday season is directed into several curriculum areas by an unusual new kit of filmstrips in color, produced by The Jam Handy Organization.

The new kit, "Christmas Series," has been class-tested for use in elementary grades. The areas to which the filmstrips may be applied are music, social studies, health, science, safety and literature.

Titles of the films are:

The Story of "Silent Night"
The Tree and Other Traditions
Santa Claus and Other Traditions
The Story of the Christmas Seal
The Christmas Tree Industry
A Safe Christmas with the Reeds

The filmstrips are in color artwork, with the exception of the filmstrip on growing Christmas trees, which is in color photography.

The series helps children to gain an appreciation of a favorite Christmas carol and its origin and acquaints them with the origin of our Christmas traditions. The Christmas Seal story is told from its interesting beginning and stresses its importance in health. Conservation principles are emphasized, and recognition of familiar Christmas trees is encouraged in the filmstrip on the tree industry. The final filmstrip creates an awareness of good safety practices during the holiday season.

The series is priced at $33.50 and individual strips at $5.95. The new kit is available through The Jam Handy Organization, 2821 East Grand Boulevard, Detroit 11, Michigan, and all authorized Jam Handy dealers.

WILL LOOK THREE TIMES FARTHER INTO SPACE

A new light-intensifying device that will allow man to look three times farther into space with the world's largest telescope, the 200-inch on Mt. Palomar, is now in the preliminary stages of development at Westinghouse Research Laboratories.

The biggest reflector will become the equivalent of a mirror 2,000 inches in diameter. This is made possible by an image multiplier that in six simple stages of electron enhancement will take the light of the Palomar telescope and increase it 10,000 to 20,000 times in brightness.

The volume of space to be reached will be some 27 times that now visible. This means that instead of being able to see back two to three billions of years in light time travel, astronomers will probe six to nine billions of light years.

Most important to theories of the constitution of the universe will be new knowledge of the distribution of the galaxies in distant space. Perhaps the moot questions of whether there is an end to space or whether space bends back upon itself will come closer to solution.

It will be at least several years before the device being pioneered by Dr. E. J. Sternglass and Milton Wachtel will be attached to the 200-inch telescope.

But a model has been built and the principles seem quite clearly worked out. Light is picked up on an electronic screen that gives out four electrons for every one that hits it. This is repeated in six stages.

An early development of the device will probably be used on smaller telescopes in connection with the International Geophysical Year.

Devices relayed to the image multiplier will allow more ability to see in the dark. These will have military and security applications. It should be able to watch an area at night without lighting it and military movements could be spotted at night from the air despite darkness that prevents ordinary photographs.

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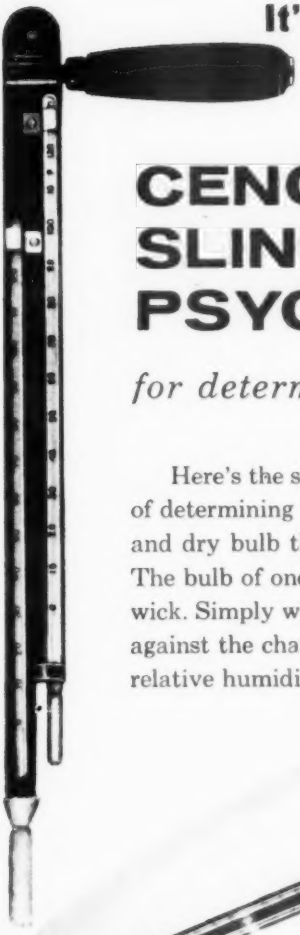

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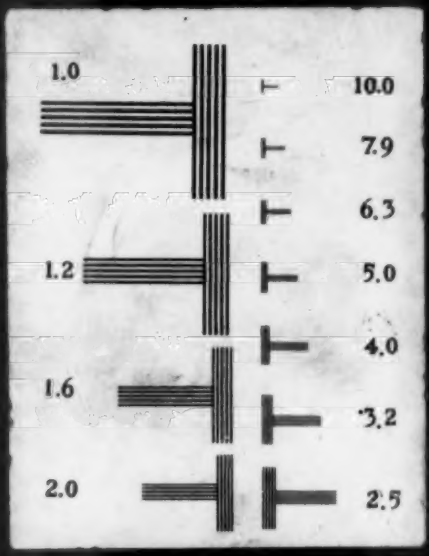

100 MILLIMETERS

INSTRUCTIONS Resolution is expressed in terms of the lines per millimeter recorded by a particular film under specified conditions. Numerals in chart indicate the number of lines per millimeter in adjacent "T-shaped" groupings.

In microfilming, it is necessary to determine the reduction ratio and multiply the number of lines in the chart by this value to find the number of lines recorded by the film. As an aid in determining the reduction ratio, the line above is 100 millimeters in length. Measuring this line in the film image and dividing the length into 100 gives the reduction ratio. Example: the line is 20 mm. long in the film image, and 100/20 = 5.

Examine "T-shaped" line groupings in the film with microscope, and note the number adjacent to finest lines recorded sharply and distinctly. Multiply this number by the reduction factor to obtain resolving power in lines per millimeter. Example: 7.9 group of lines is clearly recorded while lines in the 10.0 group are not distinctly separated. Reduction ratio is 5, and 7.9 x 5 = 39.5 lines per millimeter recorded satisfactorily. 10.0 x 5 = 50 lines per millimeter which are not recorded satisfactorily. Under the particular conditions, maximum resolution is between 39.5 and 50 lines per millimeter.

Resolution, as measured on the film, is a test of the entire photographic system, including lens, exposure, processing, and other factors. These rarely utilize maximum resolution of the film. Vibrations during exposure, lack of critical focus, and exposures yielding very dense negatives are to be avoided.